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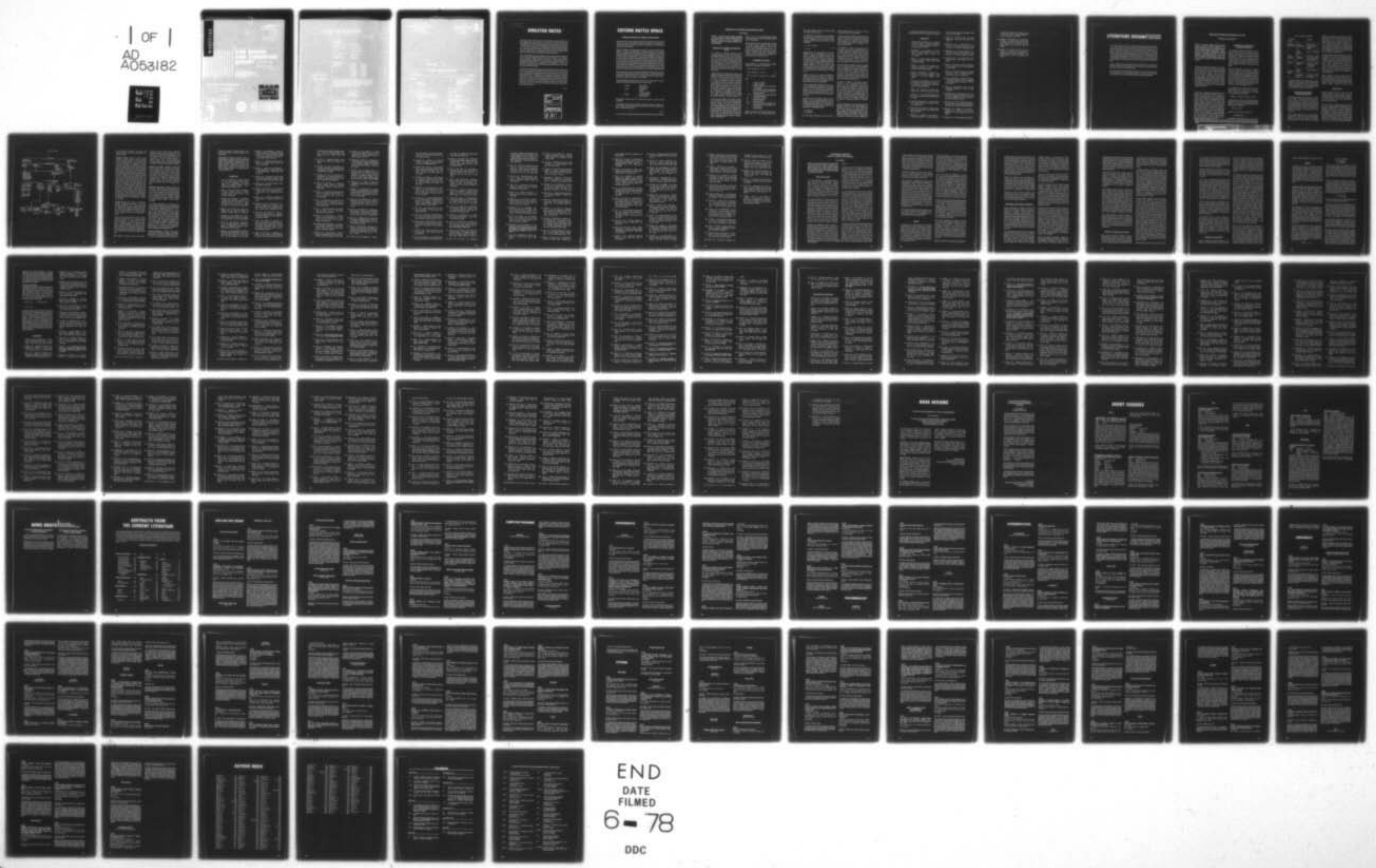

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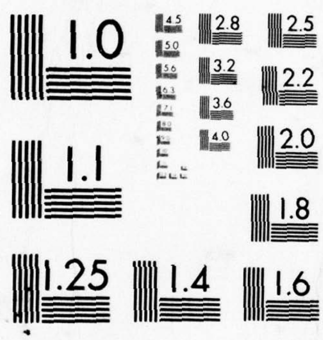

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PARAMETRIC VIBRATION,

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DIRECTOR NOTES

Last month I had a few things to say about voluntary concensus standards and their possible use by the government. I mentioned the symposium that would be held specifically to discuss the past, present, and future actions of the Department of Defense relative to the use of such standards. Since attending that symposium I am even more encouraged about the possibilities of a partnership between government and industry for the purpose of developing voluntary consensus standards to serve the needs of both. To understand how this can work it is helpful to consider how these non-government standards are presently developed.

A need is established for a specific standard by a professional society, trade association, or some other standards writing body, usually a member of the American National Standards Institute (ANSI). A writing group, almost always made up of interested users and suppliers, is formed to develop a standard acceptable to an identifiable community that is concerned about or affected by the use of the standard. If the standard is fully coordinated using ANSI procedures, it will become an American National Standard.

If government representatives participate in these standards writing activities, fully aware of the government's interests and needs as a user, there is no reason that all of the government requirements cannot be incorporated during the writing process. Properly done, the development of a standard, for example, on a vibration test procedure which is acceptable to both government and industry is entirely feasible. By not having to write a separate specification the government has saved money. Prior concurrence of all concerned parties should minimize the problem of requests for waivers of government requirements. There are a number of problems to be worked out, but I think it can be done. Recent actions indicate that at least we are going to try.

H.C.P.

EDITORS RATTLE SPACE

ABSTRACTS FROM THE CURRENT LITERATURE*

Abstracts from the Current Literature have been an important part of the DIGEST since the first issue was published in 1969. The purpose of the Abstracts is to provide the reader with short and objective descriptions of recent literature in acoustics, shock and vibration.

About 200 citations are selected each month from the more than 200 sources scanned -- journals, trade magazines, unclassified government and contractor reports, proceedings of technical meetings, and Ph.D. dissertations. Each citation includes a DIGEST accession number, title, names and addresses of authors, reference, key words, and the abstract. The citations are arranged in topical sequence so that the reader can quickly scan specific areas with minimal effort. In addition, the titles, authors, and key words of each citation are stored in a digital computer and thus are retrievable by means of the annual key-word listing. The indexing of citations, or key-word assignment has been standardized with the SHOCK AND VIBRATION THESAURUS -- an alphabetical list that has been continuously expanded since the DIGEST was first published. The THESAURUS, which contains both broadly defined and narrowly defined words, is also used in literature searches.

Citations are placed in one of the following categories: Property, object, method. Key words describe material pertinent to a given topic; for example, experimental determination, theoretical calculation, or analysis of properties of certain objects -- components, materials, or systems -- by some method.

Abstract categories are listed in issues 1, 3, 6, 9, and 12 of the DIGEST. The major categories are arranged according to property, object, method:

Property -	environments
	phenomenology
Object -	components
	systems
	computer programs
Method -	analysis and design
	experimentation

Categorization provides access on a month-to-month basis of specific topical information.

The Abstracts from the Current Literature thus give the reader an unbiased summary of recent publications pertinent to a given field so that he can decide what papers to read and study in depth.

R.L.E.

*This is the second of a series of editorials on the purpose of various sections of the DIGEST

VIBRATION OF OVERHEAD TRANSMISSION LINES

R.N. Dubey*

Abstract - This paper reviews problems associated with low-frequency vibrations of single and bundled conductors, reports on forms of instability not previously described, and describes preventive methods for galloping.

VIBRATION OF OVERHEAD TRANSMISSION LINES

The movement of overhead transmission lines is complex; oscillation can follow any of several distinct patterns, depending upon ambient conditions [11]. The motion of conductors is governed by equations that are generally nonlinear and coupled. The coupling can be through aerodynamic forcing terms [7], inertia terms, or both. The inertial coupling of Chadha [3] is due to an asymmetric mass distribution such that the mass centroid of the cross section has an eccentricity with respect to its geometric center.

A general solution of the equations of motion is not possible. The equations are simplified by assumptions dictated by the practical aspects of the problem and the nature of the solution sought. For example, if the limit cycle amplitude of motion is required, it is necessary to retain the nonlinear aerodynamic damping terms. On the other hand, if the aim is to obtain conditions conducive to initiating motion, the nonlinear aerodynamic terms can be dropped, and change in the value of tension in the conductor can be assumed to be negligibly small [23, 24]. Hence, tension during oscillations can be treated as a constant. These simplifications result in linear but coupled equations of conductor motion [3, 4].

Torsion dumbbell dampers have proved successful in controlling high frequency-small amplitude aeolian vibration. Interest in this type of oscillation has diminished somewhat in recent years. At the same time problems associated with low-frequency vibrations of single and bundled conductors have attracted increasing attention. Some forms of instability not reported earlier [7] have been observed [9, 10, 15]. A few forms have been discussed in some detail [2-5, 11, 13, 14, 17, 19, 22-26]. Preventive methods for galloping have also received considerable attention [4, 6, 12, 18, 20, 22].

Several mechanisms have been identified as capable of initiating unstable conductor motion. These include Den Hartog instability [3, 4, 7, 8], combination and/or subharmonic resonance [13, 14], parametric resonance [22], flutter due to coalescence of vertical and horizontal (out-of-plane) frequencies [19], and flutter due to coalescence of torsional and vertical frequencies [2, 4].

GOVERNING EQUATIONS

Small oscillation of a conductor about its static configuration is governed by the following:

$$m(\ddot{v} + e\cos\gamma\,\ddot{\theta}) - F_y - Tv'' = 0,$$

$$m(\ddot{w} + e\sin\gamma\,\ddot{\theta}) - F_z - Tw'' = 0, \qquad (1)$$

$$I\,\ddot{\theta} + me\,(\cos\gamma\,\ddot{v} + \sin\gamma\,\ddot{w}) - F_m - GJ\theta'' = 0$$

where

m	=	mass per unit length
I	=	moment of inertia
e	=	distance between the mass and geometric centers
γ	=	angle between the horizontal direction and the line joining the mass and geometric centers
F_y, F_z	=	aerodynamic forces along horizontal and vertical directions
F_m	=	aerodynamic moment
T	=	tension in the cable
GJ	=	torsional rigidity
u, w, θ	=	vertical, horizontal and angular displacements from the position of rest
$(\dot{\ })$	=	time derivative
$(\ )'$	=	space derivative

Equation (1) differs from the equations given in an earlier review [7] in that inertial coupling terms

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have been included, and terms involving change in tension have been neglected.

For instability due to subharmonic or combination resonance, only the second of the equations below need be considered [13, 14]. Because no inertia coupling is present, the equation of motion can be expressed as

$$\ddot{v} = c^2 v'' + \alpha \dot{v} - \beta \dot{v}^3$$
$$c^2 = T/m \qquad (2)$$

Myerscough [13, 14] solved equation (2) with the method of Krylov and Bogoliubov. He also used velocity correlation and spectral functions [14]. The solution of equation (2) led to the conclusion that galloping can occur in complex combinations of several modes. The initial disturbance significantly influences the final waveform; the result is that different conductors in the same span can have different galloping motions. Myerscough suggests a probabilistic analysis to determine the likelihood of the conductor coming close enough for outage to occur.

Borgohain and Done [1] used the Rayleigh-Ritz method to obtain natural periods for multi-span transmission lines. Their computed and experimentally observed periods were in good agreement. They ignored torsional motion in their analysis.

Among the problems encountered in solving equation (1) is the determination of aerodynamic forces and moments. They are evaluated using a quasi-steady approach [3]. Only the linear aerodynamic self-exciting terms were retained by Chadha [3, 4], who was not concerned with the limit cycle amplitude of motion.

Coupled torsional and vertical motions have been analyzed [3, 4, 22]. Galloping might be due to parametric resonance [22] or flutter when the ratio of uncoupled torsional frequency to uncoupled vertical frequency falls below a critical value [4]. The exponents 's' in the assumed solution

$$w = A \exp(st)$$
$$\theta = B \exp(st)$$

are then complex conjugate with at least one pair having a positive real part. The motion in this case can be expected to grow exponentially.

It should be remembered that an increase in tension causes an increase in the fundamental vertical frequency; as a result, the frequency ratio described above decreases. The increase in tension has been noted to cause steep rise in the intensity of conductor oscillation [16].

The condition for flutter can be realized only if the slope of the lift − α (α = angle of attack) curve is negative. Recall that the negative slope of the curve is also a prerequisite for the Den Hartog instability [7]. It would thus appear that a close link exists between the two forms of instability. Another form of galloping, which occurs in light wind and without ice on the conductor, is due to a high electrostatic field gradient on the conductor [9, 10, 15].

Bundled conductor oscillations have been discussed [2, 11, 12, 19, 25, 26]. There is common agreement that the instability is due to the vertical forces induced in the downstream (leeward) conductors that lie in the wake of the upstream conductor. The importance of the frequency ratio of the leeward conductor in determining the flutter boundaries has been shown [19] and might influence the future design of mechanical support systems.

The effect of twisting on the bundled conductor oscillation is not yet completely known and requires more study. Experimental and analytical studies suggest that stabilization of subspan oscillation occurs when the bundle is twisted through 30° per subspan [26]. Bundle twisting was found to lead to a reduction in torsional stiffness and perhaps ultimately to torsional instability [24]. An increase in the torsional frequency stabilizes the bundle; an increase in the vertical frequency tends to increase the range and possibility of instability [2].

Various mechanisms to control galloping and subconductor oscillations have been suggested and discussed [4, 6, 8, 12, 14, 18, 20]. The spacers seem to have overcome the outage problem. Pendulum weights and drag dampers have also been suggested, but both have limitations [4, 8]. A single control mechanism for all forms of instability does not appear to be feasible at present. It appears that

the mechanism responsible for instability must be identified before a control mechanism can be devised.

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LITERATURE REVIEW

survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

Current impedance analysis techniques and their applications in the design and analysis of machines are reviewed by Professor Massoud and his graduate student Mr. Pastorel of the University of Sherbrooke.

The series of review articles on parametric vibrations by Dr. R.A. Ibrahim continues with descriptions of current engineering problems on pendulum systems, shafts, machine components, hydro and aeroelastic systems, missiles, and satellites.

IMPEDANCE METHODS FOR MACHINE ANALYSIS

M. Massoud* and H. Pastorel**

Abstract - This paper considers current impedance analysis techniques and their applications in the design and analysis of machines. A background summary and basic definitions are followed by descriptions of current impedance measurement and testing techniques. Traditional applications are briefly surveyed. Recent applications have involved preventive maintenance, crashworthiness, acoustic radiation, and the environment. Relevant publications are cited.

Impedance is an observable parameter of the system. On the other hand, such parameters as mass and stiffness are known as intuitive or material parameters [9]. Although the latter are useful in analyzing passive structures, impedance has become more and more useful in analyzing complex dynamic mechanical systems. The impedance method characterizes measurable operational expressions of systems in the form of transfer functions known as mechanical imoedance or mobility. In this way a model of the system can be synthesized from experimentally measured impedances.

The history of impedance analysis dates from the 1930's; early development involved theorems of electrical network analysis [19]. The analysis of control systems played a role in advancing impedance analysis. Early applications involved vibration transmission through mounts and torsional interactions between airplane propellers and the engine, and between machines and ship hulls. A colloquium [87] on impedance analysis was sponsored by ASME in 1958. The advent of computers and progress in measurement techniques in the early 1960s made possible the direct manipulation of large quantities of data from measurements between significant points on machines [5, 11, 61, 62]. Endevco Corporation [32] reported on papers on mechanical impedance published through the mid 1960s.

MATHEMATICAL FORMULATION AND BASIC DEFINITIONS

The impedance method is particularly useful in analyzing mechanical components that can be modeled by linear systems with constant coefficients. Essentially, the impedance is the transfer function that defines the ratio of the Laplace transform of an input force at a point on the component to the Laplace transform of the output vibration at the same or some other point. Attention is thus directed toward a significant number of points on the component.

When the component is excited by a sinusoidal force, the Laplace transform becomes a frequency response; impedance is then expressed as the ratio of two complex frequency responses [38, 40, 41, 53]. The impedance functions between all significant points can be grouped in the form of an impedance matrix [33, 80]. A superposition technique -- also known as the building-block technique and mode synthesis -- is used to describe the overall performance of complex machines [34, 63, 64].

The impedance term can assume any of the definitions shown in Table 1 [19, 61, 64]. A linear component excited by a sinusoidal force is modeled by the classical second order system

$$[M]\left\{\ddot{x}\right\} + [C]\left\{\dot{x}\right\} + [K]\left\{x\right\} = \left\{f\right\}e^{i\omega t}$$

in which [M] and [K] are the mass and stiffness matrices, and $\left\{x\right\}$ is the response. When the damping matrix [C] assumes the so-called Rayleigh form $\alpha[M] + \beta[K]$, the response is

$$\left\{\dot{x}\right\} = [Z]^{-1}\left\{f\right\}$$

$$\text{where } [Z] = [\alpha + i\omega]\,[M] + [\beta + \frac{1}{i\omega}]\,[K]$$

$$= \text{impedance matrix}$$

The diagonal and off-diagonal elements of the matrix

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Table 1: Impedance Definitions

Impedance Term		Definition
Mechanical Impedance =	$\frac{\text{Force}}{\text{Displacement}}$ =	Displacement Impedance Apparent Stiffness
	$\frac{\text{Force}}{\text{Velocity}}$ =	Velocity Impedance
$\frac{\text{Force}}{\text{Response}}$	$\frac{\text{Force}}{\text{Acceleration}}$ =	Acceleration Impedance, Dynamic Mass, Apparent Weight
Mobility =	$\frac{\text{Displacement}}{\text{Force}}$ =	Displacement Mobility, Receptance, Compliance
$\frac{\text{Response}}{\text{Force}}$	$\frac{\text{Velocity}}{\text{Force}}$ =	Velocity Mobility
	$\frac{\text{Acceleration}}{\text{Force}}$ =	Acceleration Mobility, Inertance

are respectively called point impedances and transfer impedances. These elements can be measured experimentally. Comparison of the results with the mathematical expressions identifies the material parameters and modal shapes of the components [9, 86].

MEASURING INSTRUMENTS AND TEST PROCEDURES

Experimental procedures vary according to the goal of the analysis. The test techniques are not new, nor are they by any means fully developed, and the instrumentation is constantly being improved. Remmers [92] evaluated the reliability and repeatability characteristics of results of impedance tests conducted at different locations and pointed out inherent inaccuracies in the equipment and test procedures.

Any of several methods can be used to measure impedance data (Table 2). The most straightforward approach is to excite the system with a steady-state sinusoidal force and measure the sinusoidal response. This procedure is repeated over a range of frequencies in order to obtain the complete impedance matrix [5, 7, 11, 35, 36, 102]. The test is generally performed by single-point excitation. For more complex systems, however, multipoint excitation is sometimes necessary [101]. A narrow band tracking filter [61] is usually used, although wide band averaging is occasionally used. Impedance data can be displayed in the form of Bode or Nyquist plots or stored in a digital computer.

Alternate methods use such non-periodic excitations as impulses [8, 37, 74], short sinusoidal transient excitation, or a burst of random excitations [26]. Alternate methods are useful when the duration of on-test vibrations must be limited and when time-varying modal characteristics are involved. The nucleus of the equipment includes a data acquisition system and digital computers with Fast Fourier Transform (FFT) routines. Impulse transfer functions procedures with proper data processing have been described [74].

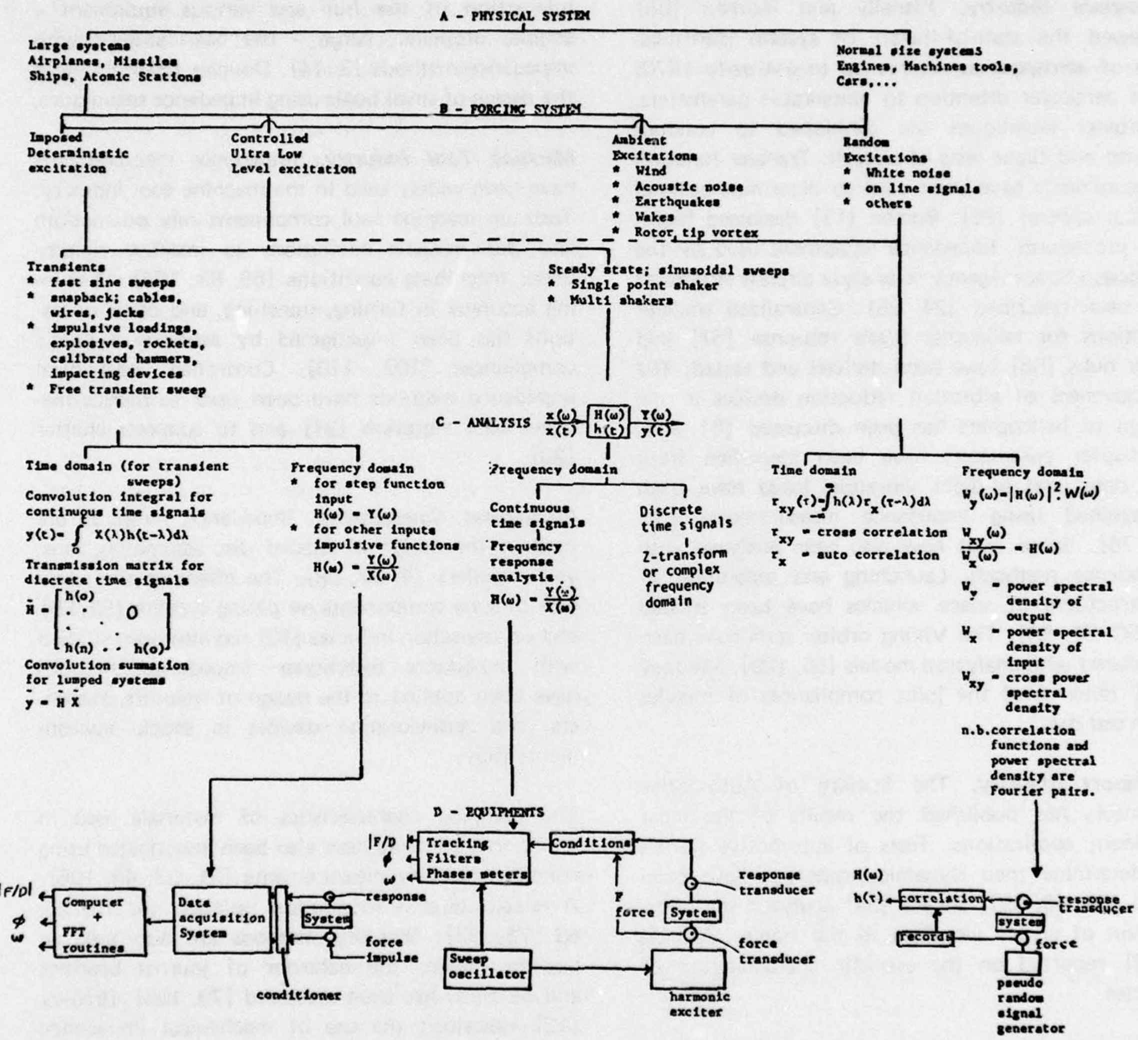
Equally important are test procedures that are based on random excitations [24, 25, 83] and can be performed without isolating the system. The random signal should have a band width considerably greater than that of the transfer function. Quasi-stationary random excitations are usually used.

APPLICATIONS

Impedance methods have in the past been used almost exclusively in vibration analysis. After the mid 1960s, when the aerospace industry successfully used the methods, the technology was transferred to industries having to do with transportation, machine tooling, and ships.

For the most part, impedance measurements have been used in dynamic design, resonance tests, system modeling, establishment of test specifications, and identification of material parameters. Mechanical weaknesses and potential failures of machines can be identified by comparing impedance data before and after periods of use. Current emphasis on noise pollution has stimulated the use of impedance measurements to investigate acoustic energy radiated from machines. Such bioengineering considerations

Table 2. Test Procedure



as man machine interaction, ride comfort, and crashworthiness are now being investigated by impedance methods.

Aerospace Industry. Flanelly and Berman [86] reviewed the state-of-the-art of system identification of aerospace structures up to the early 1970s with particular attention to measurable parameters. Improved techniques are developed to conduct ground and flight tests of aircraft. Transfer function measurements have been used to determine optimal jet-flap control [75]. Burton [17] discussed flight-test procedures. Impedance equipment used by the European Space Agency to analyze aircraft structures has been described [24, 25]. Generalized transfer functions for helicopter blade response [57] and rotor hubs [56] have been derived and tested. The effectiveness of vibration reduction devices in the design of helicopters has been discussed [81, 95]. Helicopter parameters have been identified from test data, and in-flight vibration loads have been determined using impedance measurements [38, 42, 76]. Space craft have also been analyzed with impedance methods. Launching and separation of substructures of space vehicles have been treated [6, 50, 51, 58]. The Viking orbiter tests have been correlated with analytical models [65, 109]. Maloney [72] determined the joint compliances of missiles from test data.

Transport Industry. The Society of Automotive Engineers has published the results of the most pertinent applications. Tests of automotive frames to determine their dynamic properties have been done [39, 48, 99]. Sakata [94] analyzed the transmission of engine vibration to the frame. Yoshida [113] reported on the acoustic characteristics of vehicles.

Vehicle control has been discussed using a cornering compliance concept [16, 111]. Tires have been treated according to a rolling mobility concept [78]. In locomotive design, the track/train interaction has attracted attention. Harz [45] and Vigil [108] reported on the dynamic response of trains and the impedance tests required to assess analytical models. Remington investigated several aspects of the interaction and reported on wheel/rail noise [91].

Ship Industry. The energy radiated from ship hulls has been of concern since the early 1930s, and impedance tests have been used since that time to measure this energy. Recent investigations in ship hull vibrations have been reported [18, 44]. The interaction of the hull and various equipment -- engine, propeller, cargo -- has been studied with impedance methods [3, 14]. Douglas [27] discussed the design of small boats using impedance techniques.

Machine Tool Industry. Impedance measurements have been widely used in the machine tool industry. Tests on machine tool components rely on random and deterministic excitations to improve rigidity under machining conditions [66, 83, 104]. Machining accuracy in turning, punching, and other operations has been investigated by assessing dynamic compliances [107, 110]. Controlled mechanical impedance methods have been used to reduce machine tool vibration [21] and to suppress chatter [20].

Mechanical Components. Impedance methods are used in the design of bladed disc assemblies, fans, and impellers [4, 22, 88]. The effect of the vibration of such components on piping systems [52, 98] and on cavitation inducers [13] has also been studied with impedance techniques. Impedance methods have been applied to the design of isolators, absorbers, and anti-vibration devices in shock environments [59].

The damping characteristics of materials used in shock environments have also been investigated using complex mobility measurements [31, 33, 43, 106]. A related field is foundation isolation [1, 10, 23, 69, 71, 93]. Mobility methods are also used in bearing design; the behavior of journal bearings and oil films has been discussed [79, 105]. Bradley [12] described the use of mechanical impedance measurements to correct for noise sources in gear units. Lemon [68] discussed the application of such measurements to appliance engineering problems. The transfer function of boilers has been presented [77], as has that of coil springs [55]. Stress relaxation in bolted structures utilizes compliance measurements of an assembly [73].

Preventive Maintenance. Impedance measurements have helped the engineer anticipate and prevent failures [60]. Three steps are advocated [46, 47]: a narrow band spectral analysis to identify the

frequency component of vibration signals, a transfer function analysis to identify resonance, and a modal survey.

Environments. Man/machine interactions have attracted attention. Emphasis has been on attenuating impact and the assessment of human comfort in the vehicle. Transfer function measurements for passengers have been presented [2, 15, 29, 30, 85]. Noise pollution has also stimulated interest in the study of acoustic emission by measuring acoustic mobilities [49, 96, 103].

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PARAMETRIC VIBRATION
PART IV: CURRENT PROBLEMS (2)

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Abstract - Many aspects of parametric vibrations have been studied. Current problems in engineering applications having to do with pendulum systems, shafts, mechanisms and machine components, hydro- and aeroelastic systems, and missiles and satellites are reviewed in this article.

PENDULUM SYSTEMS

The simple pendulum -- a single-degree-of-freedom system with a well defined nonlinearity -- has been used extensively to explain parametric instability [1-10]. It has also been used as a mathematical model to represent such real systems as a missile on its support base [11], a building structure [12] subjected to vertical ground motion, and a mechanism coupled to elastic elements [13]. The simple pendulum has also been used in the development of several mathematical theories [1, 2, 6, 14-17].

The dynamic stability of a simple pendulum was first examined in 1951 [18]. Skalak and Yarymovich [1] presented a nonlinear analysis to determine the steady-state response of various subharmonic orders. Their paper stimulated interest in other mathematical techniques: the well-known relationships between trignometric and Bessel functions [2]; asymptotic approximation [6-8]; the averaging method for determining transient and steady-state responses [14, 15, 19]; and others [5, 10]. The phase plane construction has been used to determine pendulum stability [17]. Jones and Robe [16] established a lemma based on Liapunov direct method and obtained the conditions for pendulum stability.

Gradewald and Moldenhauer [10] conducted experimental and analytical investigations to define the stability-instability boundaries of a simple pendulum. The effects of different forms of damping on the parametric oscillations of a pendulum system have been obtained [12, 20, 21]. Moran [22] examined the transient motions of a spherical pendulum during high frequency parametric excitation and obtained the domains of attraction of the stable steady-state motions.

Yamamoto and Saito [23] studied a vibrating double pendulum system in the presence of combination resonance. Tso and Fung [24] analyzed the effect of nonconservative forces on the dynamic stability of a double inverted pendulum. They attributed the instability of differential resonance ($\Omega = \omega_2 - \omega_1$) to follower forces and found that the effect of damping on the first region ($\Omega = 2\omega_1$) and on the combination resonance ($\Omega = \omega_2 - \omega_1$) decreased as the end load increased. As the end load approached a critical value, viscous damping rapidly lost its effectiveness and the system became highly susceptible to dynamic instability.

An elastic pendulum has been used to illustrate internal resonance [25]. Kane and Kahn [26] used the Floquet and Hamilton-Jacobi theories to explain the behavior of an elastic pendulum when detuned at $\omega_x = 2\omega_\theta$, where ω_x and ω_θ are the natural frequencies of the pendulum in the longitudinal and angular motions respectively. If the initial elongation was x and the small angle θ, the value of θ would grow with successive oscillations then decrease as a corresponding increase occurred in the spring elongation x; the process would repeat itself periodically. Such energy flow between the two modes is attributable to their nonlinear coupling. Similar results were obtained by Gordon [27] and Van der Burgh [28]. Van der Burgh [29] used the averaging method to determine the response of the elastic pendulum and compared the results with those from an analog computer.

Srinivasan and Sankar [30] analyzed the same system to determine the response for three different types of internal resonance ω_x/ω_θ = ½, 1, and 2. They found that when $\omega_x = \omega_\theta$ the response of the pendulum is complex and could lead to some form of instability due to the complicated energy transfer between the x and θ modes. These results were carefully re-examined by Van der Burgh [31] who analyzed the same system using a higher order of approximation. For the case $\omega_x = \omega_\theta$ he obtained

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a periodic solution and concluded that no resonance exists in the first order approximation of $O(\epsilon)$; hence no energy transfer takes place. The discrepancy between the results of Srinivasan and Sankar and those of Van der Burgh has been resolved [32, 33]. Recent higher order approximations for the case of $\omega_x/\omega_\theta = 2$ have been published [34, 35], as have further results concerning higher order resonances of the elastic pendulum [35a].

Broniarek and Radziszewisk [36] studied the stability of an extensible pendulum. The rheological properties of the material in the pendulum were described by the linear Voigt-Kelvin model.

The autoparametric instability and energy transfer associated with coupled differential equations of a beam-pendulum system have been investigated [37-39]. Complete energy transfer occurred between the vibrating modes when the beam frequency was twice the frequency of the simple pendulum. The instability of the system was dependent upon the initial conditions. Sethna [40] found that the amplitudes of motion are slowly varying periodic functions of time and are related to each by an elliptic relationship. It manifests itself as an energy exchange between the two modes in a slow periodic manner. His results led Haxton and Barr [41] to develop an autoparametric vibration absorber in which the excited mode is suppressed by the parametric action of the other mode.

Other structural systems have been idealized as forms of a pendulum [42-45]. Internal resonance of different orders results from the autoparametric coupling associated with the oscillating modes.

SHAFTS

The dynamics of rotating shafts and associated instabilities are important considerations in machine design. Excessive vibration and instability during operation are caused primarily by asymmetries in shafts and their support bearings [46-49]. Instabilities occur at driving speeds that are some fraction or subharmonic of a critical speed. The interaction of the symmetric parameters of a rotor and its bearing is expressed by time-dependent coefficients in the equations of motion.

The unstable regions in a vibrating four-degree-of-freedom system consisting of a rotating shaft with asymmetric flexibilities and carrying an asymmetric rotor have been investigated [47, 50, 51]. The unstable regions exist in the neighborhood of both major critical speed and at a rotating speed equal to half the sum of two natural frequencies of the system. Criteria that combine the effects of inertia and stiffness have been developed for unstable vibrations [51].

Tondl [46] studied the instabilities of a central disc on an asymmetric shaft and established equations for subharmonic instabilities due to parametric excitation. His analysis of the combined action of rotors mounted on elastically supported foundations having unequal stiffnesses in the horizontal and vertical directions indicated that instability regions of the first order occur at an angular rotational velocity close to the mean natural frequencies ω_i. One of his important conclusions was that, if the motion of a two-pole turbogenerator is stable on a high-tuned foundation, it will be even more stable on a low-tuned foundation, provided the values of foundation damping are not too greatly reduced.

Gladwell and Stammers [48] determined the instability of an asymmetrical shaft in asymmetrical bearings in three ways – using the perturbation theory, a classical method of Hill's equation developed by Whittaker, and the numerical Strum sequence. Black [52] established the equations of motion of a slender asymmetric shaft on an asymmetric support in a form applicable to Hsu's method. His study showed that parametric instability occurs not only near the critical speeds of the shaft but also near the half sums of the natural frequencies.

Ehrich [49] investigated the occasional occurrence of a beat frequency vibration signal from rotating machinery. Such instability is attributed to the simultaneous generation of two base frequency excitations, ω_1 and ω_2; one is due to rotor unbalance, and the second is associated with any of a number of other vibration sources in the machine. The excitations give rise to an apparent vibration signal at the mean frequency $(\omega_1 + \omega_2)/2$ and to a pulsation in amplitude at the difference frequency $(\omega_2 - \omega_1)$.

Messal and Bonthron [53] studied the instability in

the lateral motion of a vertical rotor consisting of an asymmetric shaft having a central disc. They found that very weak subharmonic instabilities were caused by inherent instabilities and bearing misalignment. Whirling occurred as a result of parametric excitations and other effects. Buchser [54] used eigenvalue equations to determine the stability of a noncircular shaft with a concentrated mass. Parametric vibrations caused by the nonuniform stiffness of bearing mountings were said to be unstable only in the subresonance region [55].

Studies of the effects of rotor and bearing asymmetries and of changes in the most significant instability regions and in ultraharmonic resonance due to external and internal damping [56-58] have shown that instability regions consist of two parts because of lack of symmetry in the rotor and the bearings. The character of the internal damping changes according to the magnitude of the asymmetries.

Weidenhammer [59] and Schmidt [60-62] investigated nonlinear effects on the parametric stability of rotating shafts in torsional vibration. Schmidt [62] presented amplitude response curves of shafts in the vicinity of parametric resonance.

MECHANISMS AND MACHINE COMPONENTS

Various components of industrial machines and instruments are frequently subjected to extraneous vibrations and pulsations. These excitations are transmitted to operating machines through mechanisms that act as elastic coupling elements; e.g., those associated with elastic sensing elements; electromagnetic and aeronautical instruments; and vibratory conveyers, saw blades, and belt drives. Kobrinskiy [13] and Mote [63] classified elements that can be dynamically unstable. The motion of certain mechanisms with elastic couplings can be described by a set of differential equations having periodic coefficients.

Vitkis and Ragulskis [64] determined the conditions under which the periodic motions of a class of mechanisms with two degrees of freedom could originate and their role in parametric instability. They studied motions occurring when the guided and guiding members rotated at angular velocities with an integer ratio. Kobrinskiy [13] discussed structural diagrams of mechanisms with elastic couplings and their dynamics and stability states. He introduced the concept of the dynamic-equilibrium position of a mechanism as the mean integral value of a generalized coordinate over the period of external influence. The difference in position between static and dynamic equilibria constitutes the dynamic error known among instrument manufacturers as slippage.

Tobias and Frohrib [65] examined the effect of deformation on the stability of a constrained beam-like coupler. Barr [66] investigated the parametric and autoparametric instabilities of moving beams and coupled beam systems.

Ispolov [67] illustrated the use of dampers in sprung brackets of a hoisting vessel as a way to suppress parametric instability in some machine systems. Hsu [68] determined the stability and response of a hanging string (drills) immersed in a fluid. He found that the amplitude of the response was dependent not only on the excitation parameters but also on the drag coefficient and the mass of the fluid displaced during beam oscillations. The amplitude of the response was inversely proportional to the displaced mass ratio (the ratio of fluid mass displaced to the mass of the string involved in the transverse vibration).

Bosznay [69, 70] studied the vibration characteristics of vehicles with the purpose of reducing noise. He separated the various parts of vehicles -- the engine block and parts of the driving mechanism -- and used a stiffness model of the supporting system to construct a set of linear differential equations having periodic coefficients. Porter [71] represented the crankshaft of a two-cylinder in-line reciprocating engine as a nonlinear two-degree-of-freedom system with variable inertia. The vibration of either of the normal modes of the system was half-order subharmonic and occurred only if the damping was sufficiently light. Krum [72] assessed the influence of the design of a multi-cylinder reciprocating machine on the parametric stability of the torsional vibration of the crankshaft.

Gears can be classed as couplings in machines. In some situations gear ratios fluctuate or undergo small time-dependent perturbations. Buchan [73] discussed a number of examples in which the time-

dependent gear terms show that the system is capable of absorbing energy that results in unstable divergent oscillations. Hortel [74-77] used analytical and analog simulations to determine the effect on operational stability of the variable stiffness of meshing teeth in a system of gears. He pointed out that the stiffnesses are subject to periodic alteration that cause parametric excitation.

Grybos [78] and Hortel [77] recently studied the effects of kinematic coupling. Davydov [79] examined the possibility of eliminating parametric instability in a single-stage transmission by synchronizing phases of the engagement stiffness with bearing stiffness. He recommended the development of bearings such that radial stiffness varies with time in accordance with the variation in engagement stiffness.

Other machine components that can undergo vibrational instability during operation include such axially moving parts as saw blades and belt drives. They are sometimes subjected to tension fluctuations caused either by wheel eccentricity [80] or by joints and flaws in the band [63]. The lateral vibration of strings and belts subjected to axial fluctuations has been extensively studied [81-87]. It has been found that, in the absence of damping, planar motion of a string is always unstable at sufficiently high amplitude. Naguleswaran and Williams [88], in determining the conditions for stable operation, pointed out that parametric instability is more severe than ordinary resonance and should be avoided.

Mote [84] examined the parametric instability in coupled bending-torsion of axially moving bands. Rhodes [89] demonstrated that as a belt leaves the pulley the pattern plays back in a corresponding variable tension on the next span. In addition, the belt span can be self-excited and vibrate in this way whether or not imperfections exist in either the belt or the pulleys.

HYDRO- AND AEROELASTIC SYSTEMS

Many problems of dynamic instability can arise in aeroelastic systems [90]; for example, a helicopter blade in forward flight [91-99], prop-rotor stability in oblique flight [100], and flutter of a panel attached to an oscillating wing during supersonic air flow [101-103]. Many of the systems that contain elastic elements subject to follower forces are known as flutter systems [104]. Because the fluid forces are complex, analysis of these systems is considerably more complicated than that of conventional elastic systems.

Parametric vibrations in aeroelastic elements were first examined in 1965 by Dzygadlo and Kaliski [101]. They determined the instability regions of a plate of infinite length acted upon by periodic forces in the plane of the plate and exposed on one surface to a high speed gas flow [102, 105]. The possibility that parametric and parametric self-excited vibrations could occur in rectangular multi-span plates with simply supported edges parallel to a supersonic flow has been considered [103]. Hermann and Hauger [106] established the inter-dependence of divergence, flutter, and parametric instability by showing that divergence and flutter are special cases of parametric instability. The stability of such elastic systems subjected to nonconservative forces has been thoroughly investigated [107, 108].

Paidoussis [109] considered a cantilevered cylinder in an axial flow of velocity $U = U_0 (1 + \mu \cos(\Omega t))$. The work done by the inviscid hydrodynamic forces during the course of free oscillations did not vanish. At low flow velocities negative work resulted in damping effect over and above that due to dissipation. At higher flow velocities positive work can be done by inviscid hydrodynamic forces, so that the cylinder gains energy from the flowing fluid. This is the dominant mechanism of energy transfer behind the onset of flutter in cantilevered cylinders. Parametric instability occurs only over specific ranges of flow velocity and is associated only with certain modes of the system. Blevins and Iwan [110] considered a two-degree-of-freedom system in which the natural frequencies were related in an integer multiple -- ω_θ/ω_y = 1/3, 1, and 3, where ω_θ and ω_y are the structural natural frequencies in torsion and plunge respectively. Energy exchange between the plunge and torsional modes occurred in the neighborhood of internal resonance. At $\omega_\theta/\omega_y = 1 + O(\epsilon)$, the torsional mode acted as a vibration absorber to the plunge response. Parametric and autoparametric instabilities in airplane structures have been studied [111-113].

Stammers [99] showed that the equations of motion

of a helicopter rotor blade contain periodic coefficients dependent on the azimuth angle that disappear when the helicopter hovers. He also showed that the boundary of incipient instability varies with certain mass and torsional stiffness parameters of the rotor blade and with forward speed.

Gates and DuWaldt [114] found that a blade of a helicopter in forward flight experiences a relative free stream that varies periodically; thus the proportionality of the aerodynamic forces is a periodic parameter.

Crimi [115] and Friedmann and Silverthorn [93] used a system of linear differential equations with periodic varying coefficients to describe the dynamics of a helicopter blade in forward flight. The periodic coefficients caused instability of the coupled flap-lag systems at lower values of the advance ratio; the advance ratio = $V/\Omega r$, where V is the forward speed, Ω is the rotor rotational speed, and r is the rotor radius. The results of Friedmann and Silverthorn [93] indicate that operation at certain rotating lag frequencies can improve the aeroelastic performance of hingeless blades at a high advance ratio.

Dynamical wind loading is of considerable importance in analyzing wind-induced vibration of aeroelastic structures, especially when the loading interacts with the motion of the structure. The aerodynamic forces consist of quasi-steady and unsteady components. The quasi-steady forces produce a steady drag force. An oscillatory lift force also results from vortex shedding.

One important problem in dynamic instability of wind-induced structural vibration is the resonance due to periodic wind velocity fluctuations due to atmospheric turbulence. Vaicaitis and Shinozuka [116] determined the structural response to time-dependent wind forces. Kunieda [117] recently obtained criteria necessary to establish parametric instability of a suspension roof: curvature, scales, material, and prestress of the roof and the mean wind velocity.

MISSILES AND SATELLITES

Spinning missiles and satellites are subject to aerodynamic and differential gravity effects that cause attitude motions about the position of equilibrium to become unstable [118-123]. Various periodic systems, including the symmetrical spinning body in circular or elliptic orbits, have been investigated [124-127]. Wallace and Meirovitch [128] used a set of coupled nonlinear differential equations with periodic coefficients to study nonlinear effects of a spinning satellite on the stability of the attitude motion.

The instability associated with nonlinear coupling of two vibration modes of the Transit Research and Attitude Control (TRAC) satellite has been described [118, 129]. The nonlinearities gave rise to autoparametric instability between the roll and the in-plane motion of the satellite. Pringle [129] found that, in the absence of damping, the long period of energy exchange between the two modes repeats itself indefinitely. This type of instability has been treated in a case in which a low-order commensurability existed between the frequencies of the two normal modes of the roll-yaw motion [119]. It was shown that the instability depended upon the initial amplitude and phase, the initial partition of energy between the modes, and the deviation from exact internal resonance. Likins and Wrout [130] determined the bounds of libration of resonant satellites and concluded that parametric resonance is a desirable feature of a gravity-gradient satellite. Markeev [122] studied the stability of the steady rotations of a satellite whose axis of symmetry took various positions with respect to the orbital plane for two internal resonances. He also obtained the stability conditions for two internal resonance conditions -- $\omega_1 = 2\omega_2$ and $\omega_1 = 3\omega_2$ -- using the canonical transformation of Liapunov function [131]. Alfriend [132-134] investigated the stability of the origin, periodic orbits, and non-periodic motions for similar conditions of internal resonance.

Murphy [135, 136] determined the instability of an asymmetric missile when the varying pitch frequency is equal to the constant spin frequency. The internal resonance instability in the angular motion of missiles is associated with an amplification of the nonrolling trim angle of attack [123]. Clare [137] found that detuning the rolling velocity from its resonant value gave rise to resonance jump in the steady-state case. Nayfeh and Saric [138] extended the analyses of Murphy and Clare to include nonlinear aerodynamic moments for the case of

constant stability derivatives and constant roll rate.

OTHERS

Although the basic theory of parametric instability was developed for studying elastic structural systems, the theory can be applied to other real systems in which periodic variation of parameters occurs. Examples include parametric amplifiers [139-142], electromechanical systems [143], propagation of waves in a periodic continuous medium [144, 145], and cyclotrons [146]. Some of these systems and their response to parametric excitation are reviewed below.

Parametric Amplifiers and Electromechanical Systems
Electronic circuits with periodically varying components are used as rectifier modulators or parametric amplifiers. Rectifier modulators are used when time-dependent resistance is needed in an electric circuit. Parametric amplifiers are used when time-dependent inductance, capacitance, or both are needed. The energy necessary to cause the circuit parameters to vary in the presence of a signal is transferred to the signal; thus, its energy increases with time.

Early investigations of parametric circuits date from 1897 [147-149]. The work of Mandal'shtam and Papaleksi in 1934 [149] resulted in the development of a parametric generator capable of delivering considerable power. They indicated that, if the generator circuit contains no nonlinear elements, the voltage builds to a value high enough to puncture the insulation. Minorsky [150] transformed the problem to the phase plane to study the stability of these devices.

Louisell [140] discussed the operation of degenerate parametric oscillators in which the capacitance is allowed to approach the value of the periodic variation $C = C_0 + \Delta C \cos(\Omega_p t)$. Energy is fed into or removed from the oscillator by the pump, depending on the phase of the pump relative to the voltage on the condenser. The relationship of the pump power P_p and the oscillator power P_0 was established by Manley-Rowe [151, 152] as;

$$P_p/2\omega_1 = P_0/\omega_1$$

where $\omega_1 = 1/\sqrt{LC_0}$
L = inductance
C_0 = capacitance

Another circuit should be incorporated to create a nondegenerate device. Note that ΔC must be less than the total capacitance in the circuit and that the two circuits have ideal filters. Thus one circuit supports only the frequency ω_1; the other supports only the frequency ω_2. Suhl [153] showed that the pump frequency Ω_p should equal the sum of ω_1 and ω_2.

In practice parametric amplifiers are fitted with an external signal voltage of frequency Ω_e. Non-zero currents (or voltages) are permitted at the sum and/or difference frequencies $(\Omega_e - \Omega_p)$ and at the pump frequency Ω_p when pumping is obtained by driving a dominant current through a nonlinear reactance element. Tucker [154] gave the power gain, defined as G in these amplifiers by the ratio:

$$G = (\Omega_e + \Omega_p)/\Omega_e$$

Parametric amplifiers of the so-called upper-sideband up-convertor type are based on this ratio.

Although the principles of time-dependent inductance or capacitance in an electric circuit are far from new, they were not used until comparatively recently. Now they are used in microwave receiving amplifiers [154]; a nonlinear capacitance is used in the form of a semi-conductor diode. Such amplifiers were developed when low-noise amplifiers became necessary for radar, communications, and radio-astronomy.

Some mechanical applications of parametric amplifiers have been developed by Rodgers [155]. He showed that an arrangement in which a time-dependent spring [156] is placed between two spring-mass systems can be used as a parallel vibration isolator.

Parametric excitation in mechanical systems coupled to magnetic or electric systems has been considered [157, 158]. Kaliski [142] investigated the existence of parametric magneto-elastic resonance for a perfect elastic conductor having an initial magnetic field. Moon and Pao [158] studied the interaction of an elastic beam-plate and a time-dependent magnetic field and showed that the magnetic field can cause unstable parametric excitation. Pozniak [159, 160]

determined the parametric behavior of an elastic shell and a steel core in the presence of a magnetic field. Kana [161] studied the parametric instability of a spring-mass system coupled to an electro-magnetic circuit. The coupling is an instability produced by a feedback of energy from the mechanical to the electrical part of the system.

Plasma and Coupled Waves

The parametric interaction between the decay of an electromagnetic wave and an electron plasma wave and an ion acoustic wave is well known in electrostatic oscillations [162-166]. An electromagnetic wave with frequency Ω and a wave vector $\underline{K_0}$ can feed energy into an electron plasma wave with (ω_1, K_1) and ion acoustic wave with (ω_2, K_2) if the following relations hold [163].

$$\Omega = \omega_1 + \omega_2 \qquad |\Omega| > |\omega_1|, |\omega_2|$$

$$K_0 = K_1 + K_2$$

Kono and Yajima [163] indicated that electrostatic oscillations become unstable and grow in amplitude when they gain energy from electromagnetic radiations at a rate faster than they can dissipate it by damping -- either collisional damping or Landau damping. That is to say, if the amplitude of the incident radiation exceeds a critical threshold, parametric instability occurs. Ohe and Lashinsky [167] reported on the parametric excitation of ion-acoustic waves in a fully ionized plasma. In this case the parametric excitation was accomplished by varying the plasma temperature.

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BOOK REVIEWS

STATISTICS AND PROBABILITY IN CIVIL ENGINEERING

Peter Lumb, Editor

Proceedings of the First International Conference on Applications of Statistics and Probability to Soil and Structural Engineering
Hong Kong, September 13 - 16, 1971
Hong Kong, University Press, 1972

The purpose of the conference was to promote the use of probabilistic methods and to illustrate the manner in which the methods can be applied to practical design and construction problems. The conference proceedings consist of the papers presented at six sessions; session discussions are not included.

Papers given at the first session, ***Design Philosophy -- Structures,*** are concerned with probabilistic principles and methods of structural design and reliability theory and optimization of building codes. The second session, ***Design Philosophy -- Soils,*** dealt with probabilistic analysis of soil foundations and embankments and optimal and probabilistic foundation design.

Design Parameters -- Soils, the topic of the third session, was concerned with statistical evaluation and estimation of soil properties, statistical control of sampling and testing programs, accuracy of soil tests, statistical (quality) control in pavement design (highway construction), and uncertainty caused by the variability in soil properties. The papers presented during Session 4 on ***Design Parameters -- Structural*** deal with statistical properties of reinforced concrete members, statistical variation in the fracture of steel, probability of failure of pile foundations, and statistical investigations of shell buckling.

The ***Stochastic Processes*** session was concerned with the application of stochastic processes to partially saturated soils and to the seismic liquefaction problem, vibration (buckling) of structures with random parameters (imperfections), wind loading and ocean wave force spectra, the study of a model for earthquake motions, and the estimation of dynamic properties of structures and soils under random excitations.

The final session was a general discussion of the philosophy of probabilistic design, optimization of designs, material properties and quality control, methods of computation of reliabilities, the need for application of probabilistic methods in engineering practice, and topics for future research.

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STRUCTURAL RESPONSE TO EXPLOSION-INDUCED GROUND MOTIONS

K.G. Medearis
ASCE, New York, 1975

This report deals with structural response to underground nuclear explosion in a natural gas stimulation experiment in Rio Blanco County, in western Colorado, in 1973. It is stated that ground motions produced by an underground nuclear detonation are similar to those produced by an earthquake.

Motion measurements and finite element calculations were made for five structures: a 100 ft. high, free-standing, steel truss tower; a wood frame residence; a 70 ft. high, free-standing, cylindrical tower; a college gymnasium having reinforced concrete columns; and a 75 ft. high earth dam.

Analogue velocity records were digitized to produce acceleration records. The procedures used for baseline correction, which involved low-frequency filtering, should be of special interest to those performing double-integration of acceleration data.

Velocity response spectra are given at ground level and at appropriate structural locations. Timewise measured repsonse is compared with that obtained from finite element analysis. Fourier spectra of the small micro-vibration, occurring due to such background sources as wind, microtremors, and vehicular traffic are presented.

Shear levels in four of the structures, excluding the dam, were generally found to be higher than those predicted using the Uniform Building Code seismic recommendations.

The report should be of interest to anyone concerned with measuring ground motion, processing data, and/or analyzing or designing structures for ground motion.

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SHORT COURSES

APRIL

CORRELATION AND COHERENCE ANALYSIS FOR ACOUSTICS AND VIBRATION PROBLEMS

Dates: April 24-28, 1978/Aug. 28-Sept. 1, 1978
Place: UCLA
Objective: The course covers the latest practical techniques of correlation and coherence analysis for solving acoustics and vibration problems in physical systems. Procedures currently being applied to data collected from single, multiple and distributed input/output systems are explained to classify data and systems, measure propagation times, identify source contributions, evaluate and monitor system properties, predict output responses and noise conditions, determine nonlinear and nonstationary effects, and conduct dynamics test programs.

Contact: Continuing Education in Engineering and Mathematics, U.C.L.A. Extension, P. O. Box 24902, Los Angeles, CA 90024 - (213) 825-1047.

ANTICIPATING FAILURES OF ROTATING MACHINERY WITH VIBRATION ANALYSIS

Places and Dates:

Atlanta	April 18-20, 1978
Rochester	May 2 - 4
Schenectady	May 9 - 11
Cleveland	May 23 - 25
Chicago	May 30 - June 1
Houston	June 13 - 15

Objective: This seminar is a basic course in the analysis of rotating machinery vibration. Emphasis will be on why certain machine abnormalities produce specific vibration signatures. Topics to be covered in the seminar are: the distinctions between different types of transducers and vibration monitoring equipment, causes of common machine vibratory phenomena, diagnosing machine failure modes by signature analysis, and suggestions for possible corrective action.

Contact: John Sramek, Nicolet Scientific Corp., 245 Livingston St., Northvale, NJ 07647 - (201) 767-7100, ext. 505.

QUALITY CONTROL

Places and Dates:

Philadelphia	April 10, 1978
Chicago	April 12
Los Angeles	April 14

Objective: This seminar, starting with a basic refresher course on vibration theory, describes how operating imperfections can be easily spotted and corrected. It also provides the information necessary to initiate vibration spectrum analysis checks within your own Quality Control or Quality Assurance Departments.

Contact: Bob Kiefer, Spectral Dynamics Corp., P. O. Box 671, San Diego, CA 92112 - (714) 565-8211.

MODERN ULTRASONIC SYSTEM TECHNOLOGY

Dates: April 19-21, 1978
Place: Washington, D.C.
Objective: Introduction to basic concepts of modern ultrasonic systems technology: basic features of acoustic systems and those systems reflecting the impact of ultrasonically assisted manufacture and assembly; Typical applications; Acoustic and ultrasonic system design; System implementation of the technology; System integration and ultrasonic sub-system interface; Joining and processing; Adhesive bonding; Non-metallic composites; Case studies; Discovering ultrasonic systems that work; The life cycle costs; The ultrasonic resource versus utilization of "conventional" methodology; Cost effectiveness.

Contact: Continuing Engineering Education, George Washington Univ., Washington, D.C. 20052.

MAY

PRINCIPLES AND APPLICATIONS OF NOISE CONTROL

Dates: May 4 - 6, 1978
Place: San Francisco, CA
Objective: This course, which preceeds INTER-NOISE 78, will cover fundamentals of acoustics and noise control; in-plant noise control; design of facilities for noise control, noise measurements and data reduction, and acoustical standards used in noise measurements.

Contact: INTER-NOISE 78 Conference Secretariat, P. O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 - (914) 462-6719.

FINITE ELEMENT METHOD AND NASTRAN USAGE

Dates: May 8 - June 15, 1978
Place: Troy, Michigan
Objective: A sequence of four professional development courses will be presented to provide an understanding of the technological content in general purpose finite element programs; and to provide training in the use of NASTRAN. The courses and dates are:

- Matrix Structural Analysis and Finite Elements - May 8 - 12, 1978
- Static and Normal Modes Analysis using NASTRAN - May 15 - 18, 1978
- DMAP and Substructural Analysis using NASTRAN - June 6 - 9, 1978
- Dynamic and Nonlinear Analysis using NASTRAN - June 12 - 15, 1978

Contact: Schaeffer Analysis, Kendall Hill Road, Mont Vernon, New Hampshire 03057 - (603) 673-3070.

OCEANOGRAPHIC INSTRUMENTATION

Dates: May 23 - 25, 1978
Place: University of Houston
Objective: The course will include a brief non-mathematical review of theory and the need for static and dynamic measurements. Selection of pickups will follow, together with considerations for the ocean environment. Participants will learn about readout instruments and transducers and will read both static and dynamic strain, displacement, velocity, acceleration and force. Electrical signals will be evaluated on a classroom digital signal analyzer giving immediate classroom display of dynamic physical conditions in engineering terms.

Contact: Tustin Institute of Technology, Inc., 22 E. Los Olivos St., Santa Barbara, CA 93105 - (805) 963-1124.

JUNE

ANALYSIS AND PREVENTION OF MECHANICAL FAILURES

Dates: June 15 - 16, 1978
Place: University of Michigan, Ann Arbor
Objective: To present methods for analyzing, preventing, and correcting failures of mechanical components and assemblies. Failures treated may arise from a faulty design, material, fabrication or assembly, or from operator's abuse. Interpretation of failure data will be included.

Contact: Engineering Summer Conferences, 200 Chrysler Ctr., North Campus, The University of Michigan, Ann Arbor, MI 48109.

VIBRATION SURVIVABILITY

Dates: June 5 - 9, 1978
Place: Santa Barbara, CA
Objective: Testing an equipment's ability to survive in the dynamic environments of vibration and shock and a basic education in resonance and fragility phenomena, in environmental vibration and shock measurement and analysis, also in vibration and shock environmental testing to prove survivability are the objects of this course.

Contact: Wayne Tustin, Tustin Institute of Technology, 22 East Los Olivos St., Santa Barbara, CA 93105 (805) 963-1124.

JULY

NOISE CONTROL ENGINEERING

Dates: July 31 - August 4, 1978
Place: University of Michigan, Ann Arbor
Objective: This course provides engineers and managers with comprehensive knowledge of noise-control engineering and criteria for application to practical problems.

Contact: Engineering Summer Conferences, 200 Chrysler Ctr., North Campus, The University of Michigan, Ann Arbor, MI 48109.

SEPTEMBER

7th ADVANCED NOISE AND VIBRATION COURSE

Dates: September 11 - 15, 1978
Place: Institute of Sound and Vibration Research, University of Southampton, England
Objective: The course is aimed at researchers and development engineers in industry and research establishments, and people in other spheres who are associated with noise and vibration problems. The course, which is designed to refresh and cover the latest theories and techniques, initially deals with fundamentals and common ground and then offers a choice of specialist topics. The course comprises over thirty lectures including the basic subjects of acoustics, random processes, vibration theory, subjective response and aerodynamic noise which form the central core of the course. In addition, several specialist applied topics are offered, including aircraft noise, road traffic noise, industrial machinery noise, diesel engine noise, process plant noise and environmental noise and planning.

Contact: Dr. J. G. Walker or Mrs. O. G. Hyde, Institute of Sound and Vibration Research, The University, Southampton, SO9 5NH, England.

MACHINERY VIBRATION

Dates: September 20 - 22, 1978
Place: Cherry Hill, New Jersey
Objective: Lectures and demonstrations on rotor-bearing dynamics, turbomachinery blading, and balancing have been scheduled for this Vibration Institute-sponsored seminar. The keynote address on the development of balancing techniques will be given on the first day along with sessions on modal analysis, oil whirl, and computer programs. Simultaneous sessions on rotor-bearing dynamics and turbomachinery blading will be held on the second and third days. The following topics are included in the rotor-bearing dynamics sessions: critical speeds, stability, fluid film bearing design and analysis, balancing sensitivity, generator rotor balancing, gas turbine balancing, and industrial balancing. The sessions on turbomachinery blading feature excitation and forced vibration of turbine stages, structural dynamic aspects of bladed disk assemblies, finite element analysis of turbomachinery blading, steam turbine availability, metallurgical aspects of blading, torsional-blading interaction, and field tests of turbogenerator sets. Each participant will receive a proceedings covering all seminar sessions and can attend any combination of sessions.

Contact: Vibration Institute, 101 West 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

THE FIFTH INTERNATIONAL CONFERENCE ON WIND ENGINEERING

The Fifth International Conference on Wind Engineering will be held on July 8 - 13, 1979, at Colorado State University in Fort Collins, Colorado.

Additional information and announcements will be provided by Dr. J. E. Cermak, Professor-in-Charge, Fluid Mechanics and Wind Engineering Program and Director, Fluid Dynamics and Diffusion Laboratory, Colorado State University, Fort Collins, CO 80523.

49TH SHOCK AND VIBRATION SYMPOSIUM MEETING ANNOUNCEMENT

The 49th Shock and Vibration Symposium will be held on October 17 - 19, 1978, at the International Inn, Washington, D.C. The National Aeronautics and Space Administration (Goddard Space Flight Center) will be the host. For information, contact Henry C. Pusey, Director, The Shock and Vibration Center, Code 8404, Naval Research Laboratory, Washington, D.C. 20375 - Tele. (202) 767-3306.

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

ANALYTICAL METHODS

78-499

Behaviour of an Oscillator with Even Nonlinear Damping

P.J. Holmes
Inst. of Sound & Vibration Res., The University, Southampton S09 5NH, UK, Intl. J. Nonlinear Mech., 12 (5), pp 323-326 (1977) 3 figs, 5 refs

Key Words: Oscillators, Damping effects, Numerical analysis

In this short note two theorems on the behavior of a single degree of freedom oscillator with linear stiffness and even non-linear damping terms are proven.

78-500

Computation of Functionals Over Discontinuous Sample Paths of a Stochastic van der Pol Oscillator

M. Friedman and Y. Yavin
Nuclear Res. Center, P.O. Box 9001, Beer-Sheva, Israel, Intl. J. Nonlinear Mech., 12 (5), pp 307-314 (1977) 1 fig, 5 tables, 15 refs

Key Words: Oscillators, Perturbation theory, Numerical analysis

This paper deals with a random van der Pol oscillator. It is assumed that the oscillator is subjected to two different kinds of perturbation. The first kind of perturbation is represented by the standard Wiener process and the second kind by a homogeneous process with independent increments, finite second order moments, mean zero and no continuous sample functions. In order to measure quantitatively the stochastic stability of the oscillator, two functionals are defined over its phase plane sample paths. A numerical procedure for the solution of these equations, is suggested, and its efficiency and applicability are demonstrated with examples.

NONLINEAR ANALYSIS

(See No. 510)

NUMERICAL ANALYSIS

78-501

On the Numerical Solution of Stiff Linear Systems of the Oscillatory Type

A. Ziv and V. Amdursky
IBM Israel Scientific Center, Technion City, Haifa 32 000, Israel, SIAM J. Appl. Math., 33 (4), pp 593-606 (Dec 1977) 3 figs, 9 refs

Key Words: Numerical analysis

A method is presented for the numerical solution of a stiff linear system of ordinary differential equations, $\dot{X}(t) = P(t)X(t) + F(t)$, $X(0) = X_0$. The stiffness is assumed to arise from large imaginary parts of some of the eigenvalues of P(t). The large imaginary parts cause a rapidly oscillating component to be superimposed on X(t) forcing the use of very small integration steps. This difficulty is overcome by "filtering out" the large eigenvalues making it possible to calculate the smooth component of X with a reasonable stepsize. Finally, results of numerical experiments are presented.

78-502

Numerical Determination of the Fundamental Eigenvalue for the Laplace Operator on a Spherical Domain

H. Walden and R.B. Kellogg
NASA/Goddard Space Flight Center, Greenbelt, MD, J. Engr. Math., 11 (4), pp 299-318 (Oct 1977) 4 figs, 9 tables, 15 refs

Key Words: Eigenvalue problems, Numerical analysis

Methods for obtaining approximate solutions for the fundamental eigenvalue of the Laplace-Beltrami operator (i.e., the membrane eigenvalue problem for the vibration equation) on the unit spherical surface are developed. Two types of spherical surface domains are considered: the interior of a spherical triangle, and the exterior of a great circle arc extending for less than π radians (a spherical surface with a slit). In both cases, zero boundary conditions are imposed. The fundamental eigenvalue is approximated by iteration utilizing the power method and point successive overrelaxation. Some numerical results are given and compared, in certain special cases, with analytical solutions to the eigenvalue problem. The significance of the numerical eigenvalue results is discussed in terms of the singularities in the solution of three-dimensional boundary-value problems near a polyhedral corner of the domain.

STATISTICAL METHODS

78-503

Loss and Coupling Loss Factors of Two Coupled Dynamic Systems

J.E. Brooks and G. Maidanik

David W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD 20084, J. Sound Vib., 55 (3), pp 315-325 (Dec 8, 1977) 4 figs, 1 table, 6 refs

Key Words: Statistical energy methods, Loss factor

The Statistical Energy Analysis (SEA) has been used to define and estimate the responses of complex dynamic systems. Often a complex dynamic system is modeled by dividing it into a number of subsystems - called basic dynamic systems. Within the format of SEA, the description of the model is given in terms of the loss and coupling loss factors. But to define the model, means must be devised for determining the values of these factors. This paper examines experimental methods that can be used to identify the factors. Considerations are limited to a complex consisting of two dynamic systems, but the elements for an extension to higher forms of complexes are included. The formalism is used to ascertain the sensitivity and accuracy with which the factors can be estimated. The results may thus guide experimental schemes and procedures used in modeling complex dynamic systems in the format of SEA.

VARIATIONAL METHODS

(See No. 619)

FINITE ELEMENT MODELING

(Also see No. 508)

78-504

Investigation of Dynamic Problems of Three Dimensional Models by Means of a Finite Element Technique (Untersuchung dynamischer Probleme an dreidimensionalen Modellen mit Hilfe der Finite-Element-Methode)

U. Fischer

Technische Hochschule Otto von Guericke, Magdeburg, German Dem. Republic, Maschinenbautechnik, 26 (9), pp 388-390 (Sept 1977) 7 refs

(In German)

Key Words: Finite element technique, Natural frequencies, Mode shapes

In the article equations of motion and the determination of natural frequencies of three dimensional viscoelastic structures are discussed. It is shown that the finite element technique is particularly suitable for generating large quantities of data for undamped and damped systems, as well as forced vibrations.

MODELING

(See Nos. 572, 601)

DIGITAL SIMULATION

78-505

Computer Simulation of a Reciprocating Compressor with Special Emphasis on the Prediction of Dynamic Strains in Ring Type Valves

K.H. Reddy

Ph.D. Thesis, Purdue Univ., 257 pp (1974)

UM 77-30,040

Key Words: Compressors, Valves, Digital techniques

The object of this study was to simulate a reciprocating compressor having ring type valves to predict the valve strain. The validity of the model was tested by predicting the tangential strain at several points on a suction valve of a 5 H.P. compressor, the radial strain being very small. The valve dynamics were modeled using the modal expansion technique. The natural frequencies and mode shapes were measured experimentally.

SURVEYS AND BIBLIOGRAPHIES

78-506

Shipboard Shock Environment and Its Measurement

M.W. Oleson and R.O. Belsheim

Naval Research Laboratory, Washington, D.C., Shock Vib. Dig., 9 (12), pp 3-12 (Dec 1977) 9 figs, 8 refs

Key Words: Reviews, Shipboard equipment response, Shock response, Underwater explosions

This paper contains a review and description of ship shock environments caused by adjacent explosions. The responses of a ship's structure and equipment to these environments are also discussed.

78-507
Response and Failure of Simple Structural Elements Subjected to Blast Loadings
C.A. Ross, W.S. Strickland, and R.L. Sierakowski
Univ. of Florida Graduate Engrg. Center, Eglin AFB, FL 32542, Shock Vib. Dig., 9 (12), pp 15-26 (Dec 1977) 11 figs, 2 tables, 13 refs

Key Words: Reviews, Beams, Plates, Cylindrical shells, Blast response, Experimental data

This paper is a review of experiments involving basic structural elements such as beams, plates, and cylindrical shells that have been exposed to mild blast loadings. The response and subsequent failure of these structural elements are described in some detail.

78-508
The Finite Element Applied to the Analysis of Mechanisms and Machines
R.C. Winfrey
Digital Equipment Corp., Maynard, MA 01754, Shock Vib. Dig., 9 (12), pp 27-33 (Dec 1977) 4 figs, 44 refs

Key Words: Reviews, Finite element technique

This review contains a survey of some approaches to the analysis of mechanisms. Complex models are described, as are various problems associated with the use of finite elements in such analyses.

78-509
Scaling and Modeling for Experiment
G. Murphy
Dept. of Engrg., Iowa State Univ., Ames, IA 50010, Shock Vib. Dig., 10 (1), pp 5-13 (Jan 1978) 76 refs

Key Words: Reviews, Scaling, Test models

This article is concerned with the design of scale models which consider shock and vibration phenomena. They are divided into fluid dynamics, vibration and flutter, acoustics, structural impact, explosions, and seismic response.

78-510
Parametric Vibration. Part I: Mechanics of Linear Problems
R.A. Ibrahim and A.D.S. Barr
Arab Organisation for Industrialisation, Sakr Factory for Developed Industries, P.O. Box 33, Heliopolis, Cairo, Egypt, Shock Vib. Dig., 10 (1), pp 15-29 (Jan 1978) 4 figs, 132 refs

Key Words: Reviews, Parametric vibration, Nonlinear theories

This survey of the theory of parametric vibration and its related current problems consists of five review articles. The titles are: I. Mechanics of Linear Problems. II. Mechanics of Nonlinear Problems. III. Current Problems (1). IV. Current Problems (2). V. Stochastic Problems.

78-511
Dynamic Analysis for Rigid-Link Mechanisms
R.C. Dix
Illinois Inst. of Technology, Chicago, IL 60616, Shock Vib. Dig., 10 (1), pp 31-33 (Jan 1978) 15 refs

Key Words: Reviews, Linkages, Mechanisms, Computer programs

This article surveys the latest computer-based methods for dynamic analysis of rigid-link mechanisms. Some of the various techniques presented have been converted to commercially available, user-oriented programs. Others can be used to further reserach.

MODAL ANALYSIS AND SYNTHESIS

(Also see No. 557)

78-512
Methods for the Calculation of the Effect of Parameter Changes on the Natural Frequencies of Vibrating Systems (Methode zur Berechnung des Einflusses von Parameteränderungen auf die Eigenfrequenzen von Schwingungssystemen)
H. Dresig
TH Karl-Marx-Stadt, Sektion MB, Maschinenbautechnik, 26 (9), pp 427-430 (Sept 1977) 1 fig, 2 tables, 3 refs
(In German)

Key Words: Natural frequencies, Machinery

A method of calculation is described which enables computation of changes in natural frequency of linear vibration systems resulting from mass and spring parameter changes. This approximation method simplifies the calculation procedure and is applicable to a large number of problems for the analysis and/or synthesis of machinery.

COMPUTER PROGRAMS

GENERAL

(Also see Nos. 511, 529, 562, 600, 625)

78-513

Computer Program for the Analytical Assessment of Flexibly Connected Barge Trains. Volume 1: Users Manual

D.L. Brown, J.E. Marriner, and D.B. McFarland
Barge Train, Inc., Long Beach, CA., Rept. No. MA-RD-940-77088, 133 pp (July 1977)
PB-272 998/6GA

Key Words: Barges, Flexible couplings, Dynamic response, Computer programs

The program described in this report was developed to define the dynamic response of a flexibly connected barge train proceeding with a constant velocity. Methods of elastomechanics are utilized to define the flexibility of the connector system. The theoretical development and complete user oriented information is presented. Examples of input data, program execution and output data are also presented.

78-514

Computer Program for the Analytical Assessment of Flexibly Connected Barge Trains. Volume 2: Appendices. A. Program Listings. B. Sample Problem. C. Verification. D. References

D.L. Brown, J.E. Marriner, and D.B. McFarland
Barge Train, Inc., Long Beach, CA, Rept. No. MA-RD-940-77089, 183 pp (July 1977)
PB-272 999/4GA

Key Words: Barges, Flexible couplings, Dynamic response, Computer programs

The program described in this report was developed to define the dynamic response of a flexibly connected barge train proceeding with a constant velocity. Methods of elastomechanics are utilized to define the flexibility of the connector system. The theoretical development and complete user oriented information is presented. Examples of input data, program execution and output data are also presented. Appendices are included in Volume 2 which present the program listings, sample problem results and program verification.

78-515

NATFREQ. A Computer Program for Calculating the Natural Frequency of Rotating Cantilevered Beams

J.B. Wilkerson
Aviation and Surface Effects Dept., David W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD., Rept. No. DTNSRDC/ASED-370, 49 pp (Jan 1977)
AD-A045 587/3GA

Key Words: Computer programs, Cantilever beams, Helicopter rotors, Rotary wings, Natural frequencies, Mode shapes

A computer program was developed to evaluate the natural frequencies of model helicopter rotor blades for use in wind tunnel evaluations. This program, NATFREQ, calculates the uncoupled natural frequency and corresponding mode shape of the first, second, and third natural bending modes for a nonuniform cantilever beam rotating in a vacuum. The program includes centrifugal stiffening effects and allows for arbitrary radial distributions of blade mass and stiffness properties. The fundamental uncoupled torsional natural frequency may also be calculated for a nonrotating cantilevered nonuniform beam.

78-516

Application of the RASTADYN Computer Program (Erfahrungen bei der Anwendung des Programmsystems RASTADYN)

L. Franz and S. Schönfeld
Technische Hochschule Karl-Marx-Stadt, Sektion Verarbeitungstechnik, Maschinenbautechnik, 26 (9), pp 419-422 (Sept 1977) 3 figs, 20 refs

Key Words: Mathematical models, Computer programs, Structural members, Beams

Several applications of the computer program RASTADYN, written at the Technical University of Karl-Marx Stadt, are presented. Among the problems discussed are modeling of structural members and groups by means of beam elements. Cost and efficiency are discussed in detail.

RANDOM RESPONSE

(See No. 627)

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 543, 549, 604, 610)

78-517

Aeroacoustic Performance of a Scoop Inlet

J.M. Abbott

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-73725; E-9277, 14 pp (Oct 1977) N77-32837

Key Words: Engine noise, Wind tunnel tests

A low speed wind tunnel test demonstrated the aerodynamic and acoustic performance of a scoop inlet. Engine noise is directed upward by the extended lower lip of the scoop inlet. In addition, more of the scoop airflow comes in from above the inlet than below, leading to relatively higher surface velocities on the upper lip and lower surface velocities on the lower lip. These lower velocities on the lower lip result in a higher attainable angle of attack before internal flow separation occurs.

78-518

Assumptions and Results in the Computation of Structure-Borne Sound Excitation by Machines in Buildings. Parts I and II (Voraussetzungen und Ergebuisse bei der Berechnung der Körperschallanregung von Gebäuden durch Maschinen)

R. Melzig-Thiel and G. Meltzer

Zentralinstitut f. Arbeitsschutz, Dresded, Maschinenbautechnik, 26 (7), pp 306-310 (July 1977), & 26 (8), pp 371-374 (Aug 1977) 12 figs, 1 table, 11 refs (In German)

Key Words: Machinery vibration, Noise generation, Noise measurement

The assumptions needed for the application of the proposed calculation method, as well as the possibilities for the derivation of operands and meaningful approximations are explained by means of examples.

78-519

A Study of Traffic Noise Attenuation Around Buildings

J.S. Bradley

Faculty of Engrg., Univ. of Western Ontario, London, Canada, Acustica, 38 (4), pp 247-252 (Oct 1977) 7 figs, 1 table, 5 refs

Key Words: Buildings, Traffic noise, Noise reduction

The attenuations of traffic noise caused by buildings acting as barriers were measured at sites of single rows of detached houses, and at sites of multiple residence buildings. For the sites of detached houses, attenuations were calculated manually including the geometrical and diffraction propagation effects at each observation point. Predictions were made for the multiple residence sites using computer based techniques.

78-520

Theory and Methods for Modelling Acoustically-Long, Unpartitioned Cavity Resonators for Engine Exhaust Systems

J.W. Sullivan

Ph.D. Thesis, Purdue Univ., 170 pp (1974)
UM 77-30,043

Key Words: Cavity resonators, Engine noise, Mathematical models

Two separate, and distinctly different, theories are developed for modeling the performance of acoustic resonators of the type where the center tube is perforated over the length of the cavity; and where the frequency range of operation extends beyond the range of validity of the classical branch theory.

78-521

The Effect of Motion on Acoustic Dipole Models for Aerodynamic Noise Prediction

W.F. King, III

Inst. f. Turbulenzforschung, Deutsch Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Berlin, West Germany, Rept. No. DLR-1B-257-77/7, 9 pp (1976)
N77-32847

Key Words: Aircraft noise, Noise prediction

The effect of motion on acoustic dipole models for aerodynamic noise is shown to alter their directivity patterns. When this effect is included in an analysis of airframe noise

measurements, directivity patterns computed with acoustic surface dipoles are in better agreement with observations than those obtained with edge dipole sources.

78-522

On the Effect of Spatial Source Coherence on the Radiation of Jet Noise

A. Michalke

Hermann-Föttinger-Institut f. Thermo- und Fluiddynamik, Technische Universität Berlin, Berlin, Germany, J. Sound Vib., 55 (3), pp 377-394 (Dec 8, 1977) 12 figs, 1 table, 16 refs

Key Words: Jet noise

The effect of spatial source coherence on jet noise has been investigated theoretically for a normalized cross-spectral density of the source quantity based on a convected Gaussian form and for different special source intensity distributions, Lighthill's approach being used. As a coherence parameter the ratio of two length scales has been introduced which characterize the spatial extension of the coherence and source volumes.

78-523

Interim Noise Correlation for Some OTW Configurations Using External Jet-Flow Deflectors

U. VonGlahn and D. Groesbeck

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-73746; E-9317, 27 pp (Oct 1977) Sponsored by AIAA

N77-32838

Key Words: Jet noise, Aircraft noise

Jet flap interaction acoustic data obtained statically from a model-scale study of STOL-OTW configurations with a conical nozzle mounted above the wing and using various external deflectors to provide jet-flow attachment are correlated. The acoustic data are correlated in terms that consider the jet/flap interaction noise contributions associated primarily with fluctuating lift, trailing edge, and configuration wake noise sources. Variables considered include deflector geometry, flap setting and wing size. Finally, the configuration overall noise levels are related to static lift and thrust measurements in order to provide insight into possible acoustic/aerodynamic performance trade-off benefits.

78-524

The Effect of Flight on the Noise of Subsonic Jets

B.J. Cocking

National Gas Turbine Establishment, Pyestock, UK, Rept. No. NGTE-R-343; BR55165, 37 pp (Oct 1976)

N77-32850

Key Words: Jet noise, Wind tunnel tests, Experimental data

The noise of a single-stream circular jet and a coaxial jet with coplanar nozzles of 2.5 area ratio has been measured under simulated flight conditions in the RAE 24 ft wind tunnel. The majority of tests were conducted with the single-stream jet and primary section of the coaxial jet at a nominal temperature of 880 K. The data were used to quantify the effect of jet temperature and were combined with measurements from an earlier test series to establish a prediction method for the effect of flight on the noise of single-stream subsonic jets.

78-525

Multimodal Far-Field Acoustic Radiation Pattern: An Approximate Equation

E.J. Rice

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-73721, 12 pp (Oct 1977)

Sponsored by AIAA

N77-32160

Key Words: Ducts, Elastic waves

The far-field sound radiation theory for a circular duct was studied for both single mode and multimodal inputs. The investigation was intended to develop a method to determine the acoustic power produced by turbofans as a function of mode cut-off ratio.

78-526

Parabolic Equation Predictions Compared with Acoustic Propagation Measurements from Project Tasman Two

K.M. Guthrie and D.F. Gordon

Naval Ocean Systems Ctr., San Diego, CA., Rept. No. NOSC/TR-133, 41 pp (Aug 1977)

AD-A045 120/3GA

Key Words: Underwater sound, Sound transmission

The parabolic equation method for computing acoustic propagation losses was used to model the results of the Tasman Two Sea Tests. In these tests aircraft dropped SUS (signals, underwater sound) charges along four great circular paths from a hydrophone near South Island, New

Zealand, in westerly directions across the South Tasman Sea and Southeast Indian Ocean. The data were processed in 1/3 octave bands from 16 to 1000 Hz. The best available sound speed, bathymetric, and sediment data were compiled both from Tasman Two Sea Tests data and from historical data. These data were used to make parabolic equation runs along the radials starting at the stationary receiver for 63 and 125 Hz.

78-527

Frequency Independent Acoustic Antenna

R.L. Sternberg

Dept. of the Navy, Washington, D.C., PAT-APPL-784 186/GA, 14 pp (Apr 4, 1977)

Key Words: Antennas, Underwater sound

A frequency independent log periodic acoustic device is utilized for the transmission or reception of underwater sound. The acoustic device when used in conjunction with any substantially plane wave receiving or transmitting transducer produces a directional, substantially constant beamwidth diffraction pattern for radiation or reception of underwater sound signals.

78-528

Mode-Selective Sound Transmission in a Fluid-Filled Waveguide with Transverse Resistivity

E.A.G. Shaw

Div. of Physics, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6, Acustica, 38 (4), pp 224-235 (Oct 1977) 9 figs, 2 tables, 8 refs

Key Words: Sound transmission, Waveguide analysis

A theory is given for plane waves in a fluid medium with flow-resistivity transverse to the principal axis. The transverse phase and axial attenuation constants are expressed as functions of parameters which specify the wavefront direction and resistivity. The theory is extended to include a structural mass associated with the resistivity.

SEISMIC

(See Nos. 541, 609, 623)

SHOCK

(Also see Nos. 506, 507, 534, 588)

78-529

Optimum Dynamic Design of Nonlinear Reinforced Concrete Slabs under Blast Loading

J.M. Ferritto

Civil Engrg. Lab (Navy), Port Hueneme, CA., Rept. No. CEL-TN-1494, 49 pp (July 1977)

AD-A045 465/2GA

Key Words: Computer programs, Reinforced concrete, Containment, Blast response, Optimum design

A computer program was developed to determine the nonlinear dynamic response of reinforced concrete slabs subjected to blast pressure loading. Given the explosive parameters and geometry of the slab, the program computes the blast environment and the structural resistance, mass, and stiffness of the slab and solves for the dynamic response. The program contains optimization subroutines that provide for automatic optimum design of least-cost structural slabs. It will assist engineers in the design and analysis of facilities that are intended to contain the effects of accidental explosions. The report gives a user's guide and sample problems with data input and program output.

78-530

An Energy-Absorbing Frangible-Tube Bridge Barrier System

K.R. Lane

Bureau of Planning and Res., Connecticut Dept. of Transportation, Wethersfield, CT, Rept. No. FHWA/CT/RD-361-F-77-2, 35 pp (Apr 1977)

PB-272 954/9GA

Key Words: Bridges, Guardrails, Collision research (automotive)

An energy-absorbing frangible-tube bridge barrier system has been installed on Interstate Route 84 on a 4 degrees 10 minutes horizontal curve. The system is recommended for use on similar bridges where the probability of high-accident frequencies is known.

PHENOMENOLOGY

DAMPING

(Also see No. 499)

78-531

Dynamically Damped Floating Platforms

A. Baz

Cairo Univ., Cairo, Egypt, ASME Paper No. 77-Pet-58

Key Words: Dampers, Floating structures

This paper deals with the analysis of the dynamics of a passively damped class of floating platforms during their heave oscillations on the wavy sea surface. The passive damper mechanism has been suggested as a simple means for attenuating the amplitudes of such oscillations.

78-532

Extensional and Shear Strain Damping Mechanisms in Constrained Layer Damped Vibration

J.N. Rossettos and E. Perl

Northeastern Univ., Boston, MA 02100, ASME Paper No. 77-DET-74

Key Words: Layered damping

The analysis of the plane strain forced vibratory response of a slightly curved, layered plate consisting of a symmetrical cross-ply composite base plate, and a constrained damping layer is presented. A nondimensional variational statement together with the parameters governing the problem is derived.

78-533

Study of Vibration in Concrete. Report 3. Mechanics of Motion of Fresh Concrete

A.M. Alexander

Army Engineer Waterways Experiment Station, Vicksburg, MS, Rept. No. AEWES-TR-6-780-3, 58 pp (Sept 1977)

AD-A045 158/3GA

Key Words: Concretes, Mechanical impedance

Mechanical impedance tests on fresh concrete revealed the properties that resist motion.

78-534

Shock Response of Viscoelastically Damped Beams

A.D. Kapur, B.C. Nakra, and D.R. Chawla

Dept. of Mech. Engrg., Punjab Engrg. College, Chandigarh, India, J. Sound Vib., 55 (3), pp 351-362 (Dec 8, 1977) 8 figs, 3 tables, 18 refs

Key Words: Viscoelastic damping, Layered damping, Beams, Shock response

Analysis for the dynamic response of two layer and three layer viscoelastically damped beams subjected to half sine shock excitation were performed. Effects of rotary and longitudinal inertias were included in the analysis in addition to the effects of transverse inertia. The constants of the model were determined for a viscoelastic material for which properties are known for maintained harmonic excitation. Experimental verification of the analytical results for strain response due to shock excitation is reported.

78-535

Polymer Damps Vibration and Noise by Converting Dynamic Energy to Heat

Product Engr. (N.Y.), 48 (12), pp 27-28 (Dec 1977) 2 figs

Key Words: Viscoelastic damping, Material damping

Bonding thin viscoelastic material to vibrating structures, unwanted vibration is dampened effectively. Material is low in cost and easy to apply. An application for damping the noise levels of saw blades during cutting is described.

FLUID

(Also see No. 561)

78-536

Drag on an Oscillating Airfoil in a Fluctuating Free Stream

S.B.R. Kottapalli

Ph.D. Thesis, Georgia Inst. of Tech., 161 pp (1977)

UM 77-28,579

Key Words: Airfoils, Helicopter rotors, Rotor blades (rotary wings), Fluid-induced excitation

An analytical study is presented regarding the unsteady skin friction drag of an oscillating airfoil exposed to a fluctuating free stream speed. One application of the results from such an investigation is in aeroelastic stability analyses of helicopter rotor blades undergoing pitching, flapping, and lead-lag (in-plane) types of oscillation. The flow, which of course is time-dependent, is considered to be incompressible and two-dimensional. Both laminar and turbulent conditions are covered in the analysis.

EXPERIMENTATION

DIAGNOSTICS

(Also see Nos. 552, 553, 554, 621, 624)

78-537

Diagnosis in Operation of Bearing Misalignments in Turbogenerators

A. Clapis, G. Lapini, and T. Rossini

CISE, Segrate, Milano, Italy, ASME Paper No. 77-DET-14

Key Words: Bearings, Alignment, Diagnostic instrumentation

This paper presents a technique for the operational diagnosis of turbogenerator bearing misalignments, based on standard surveillance instrumentation. Experimental results obtained on a 70-MWe turbogenerator with artificially misaligned bearings are included. A series of measurements performed on a 320-MWe turbogenerator where one bearing was temporarily misaligned are reported.

78-538

Torsional Vibration of Machine Systems

R.L. Eshleman

Vibration Institute, Clarendon Hills, IL 60514, Proc. 6th Turbomachinery Symp., pp 13-22 (Dec 1977) 10 figs, 4 tables, 9 refs

Sponsored by Dept. of Mech. Engrg., Gas Turbine Labs, Texas A&M Univ., College Station, TX

Key Words: Torsional vibration, Diagnostic techniques, Shafts, Vibration measurement, Measurement techniques

This paper is concerned with torsional vibration in the design, development, and fault diagnosis and correction of machine systems. The physical behavior of torsional vibrations in shafting systems and sources of torsional excitation are reviewed. The concepts of torsional natural frequencies, critical speeds, resonance, and response (forces, stresses, and motions) are explained. The measurement of torsional vibration in both the field and the laboratory is described; monitoring and problem correction are emphasized. Systems subjected to torsional vibrations are used to illustrate measuring techniques.

78-539

Machinery Monitoring Update

V.R. Dodd

Chevron U.S.A. Inc., Pascagoula, MS., Proc. 6th Turbomachinery Symp., pp 23-31 (Dec 1977) 8 figs

Sponsored by Dept. of Mech. Engrg., Gas Turbine Labs, Texas A&M Univ., College Station, TX

Key Words: Turbomachinery, Diagnostic techniques

This paper describes and economically justifies one major oil company's utilization of a total Integrated Mechanical Inspection Program as an alternative to high maintenance costs and reduced plant productivity.

78-540

Use of In-Field Computer for Balancing High Power Turbomachinery

R. Bigret, A. Curami, C. Frigeri, and A. Macchi

Ente Naxionale per L'Energia Elettrica, Enel-Centro Ricerca Termica E Nucleare, Milano, Italy, ASME Paper No. 77-DET-11

Key Words: Turbomachinery, Balancing techniques, Computer aided techniques

A modified influence coefficient method has been successfully applied for multispeed, multiplane balancing of a 235-MW turbomachine. A weighted least-squares optimizing algorithm has been employed. The computations have been programmed for a digital computer operating in the field. The theory of the problem and the measuring techniques used to determine the bearing vibration amplitudes and phase angles are described in this paper, together with some experimental results.

EQUIPMENT

78-541

Simulation Techniques in Seismic Qualification of Category 1 Auxillary Equipment

D.B. Longinotti

De Laval Turbine, Inc., Oakland, CA., ASME Paper No. 77-DGP-18

Key Words: Equipment response, Seismic response

This paper describes techniques for simulating operating conditions during seismic qualification testing required by the Nuclear Regulatory Commission for equipment which

will be used for nuclear standby power applications identified as seismic category I. Approaches to simulating operating conditions are discussed for various equipment including pumps, filters, heat exchangers, valves, governors, and control panel assemblies to show how verification of satisfactory operation during and after a given seismic event can be accomplished.

78-542
Digital Experimental Techniques for Troubleshooting Vibration Problems in Rotating Equipment
S.A. Beck
Structural Dynamics Research Corp., Cincinnati, OH, ASME Paper No. 77-PVP-49

Key Words: Equipment response, Digital techniques, Computer aided techniques

The purpose of this paper is to breifly review state-of-the-art troubleshooting techniques for solving vibration problems commonly associated with power generation and petrochemical industry rotating equipment. Emphasis is placed on more advanced techniques involving the use of minicomputers.

FACILITIES

78-543
Propeller Acoustics Test Facility (Capability Description)
P.A. Shahady, S.W. Kizirnis, and R.M. McGregor
Air Force Aero Propulsion Lab, Wright-Patterson AFB, OH 45433, Rept. No. AFAPL-TR-77-48, 100 pp (Aug 1977)
AD-A045 409/0GA

Key Words: Test facilities, Noise generation, Fans, Propellers

This report describes the development of a research facility to investigate fan and propeller noise generation mechanisms.

INSTRUMENTATION
(Also see No. 537)

78-544
Holography and Applications (Generalites sur L'Holographie et ses Applications)
P. Smigielski
Institut Franco-Allemand de Recherches, St. Louis, France, Rept. No. ISL-C0-209/76, 44 pp (Aug 30, 1976)
(In French)
N77-32471

Key Words: Holographic techniques, Interferometers

A review of the history and physical principles of holography is presented. Applications using interferometric holography are discussed with regard to nondestructive tests, dimensional control, dynamic measurement of deformations, hydrodynamics, and turbine blade vibrations.

78-545
Amplitude, Time, and Frequency Statistics of Quasi-Impulsive Noise
W.D. Bensema
National Bureau of Standards, Washington, D.C., Published in Proc. of 1977 EMC Symp., Montreux, Switzerland, pp 347-352 (June 18-30, 1977)

Key Words: Noise measurement, Measuring instruments

A portable, multichannel battery-operated measurement system was developed to measure the rms magnetic-field noise spectrum in the frequency range from 100 Hz to 375 kHz. During each measurement, the entire spectrum is measured simultaneously through the use of time-domain recordings which are later analyzed by Fast Fourier Transform (FFT) processing.

78-546
A Noise Spectrum Measurement System Using the Fast Fourier Transform
W.D. Bensema
National Bureau of Standards, Washington, D.C., Published in IEEE Transactions on Electro-Magnetic Compatability EMC-19, n2, pp 37-43 (May 1977)

Key Words: Noise measurement, Measuring instruments, Fast Fourier Transform

A portable, multichannel battery-operated measurement system was developed to measure the rms magnetic-field noise spectrum in the frequency range from 100 Hz to 375 kHz. During each measurement, the entire spectrum is measured simultaneously through the use of time-domain recordings which are later analyzed by Fast Fourier Transform (FFT) processing.

78-547

Fluid Mechanical Model of the Helmholtz Resonator

A.S. Hersh and B. Walker

Hersh Acoustical Engineering, Chatsworth, CA., Rept. No. NASA-CR-2904, 74 pp (Sept 1977) N77-32835

Key Words: Helmholtz resonators, Acoustic impedance

A semi-empirical fluid mechanical model of the acoustic behavior of Helmholtz resonators is presented which predicts impedance as a function of the amplitude and frequency of the incident sound pressure field and resonator geometry. The two-microphone method was used to measure the impedance of a variety of resonators. The data were used to refine and verify the model.

78-548

Study of a Rotary-Drive Vibratory-Output Accelerometer

H. Yamada

National Aerospace Lab., Tokyo, Japan, Rept. No. NAL-TR-342T, 14 pp (Mar 1977)
N77-32460

Key Words: Accelerometers

An accelerometer is described, which is equipped with a rotary-drive vibratory-output to obtain inertial acceleration, as an inertial guidance component of a rocket vehicle, as well as other such applications. The accelerometer has the advantage of eliminating cross coupling error due to acceleration along nonsensitive axes of the accelerometer. A trial production accelerometer was produced and tested. This accelerometer was constructed by mounting an unbalanced mass rotor and a centrifugal pendulum in a gimbal and employs tuned Coulomb frictionless suspension to provide electrical damping for the gimbal. The function and theory of operation of the accelerometer is explained. Experimental results obtained from the trial production accelerometer are presented and were found to agree with the theoretical predictions. The results show acceleration resolution to be of the order based on a unity signal-to-noise ratio, and confirm the practicability of the accelerometer.

78-549

The Measurement of the Acoustic Impedance of Brass Instruments

R.L. Pratt, S.J. Elliott, and J.M. Bowsher

Dept. of Physics, Univ. of Surrey, Guildford, Surrey, UK, Acustica, 38 (4), pp 236-246 (Oct 1977) 13 figs, 35 refs

Key Words: Musical instruments, Acoustic impedance, Measuring instruments

An apparatus is described which is largely free of the limitations of earlier methods of measuring the input impedance of brass instruments. The concept of acoustic impedance is discussed and those earlier methods are briefly reviewed and are shown to suffer from several disadvantages. Results of measurements on trombones using the new apparatus are illustrated and an indication of the way that computer processing may aid analysis and interpretation is given.

SCALING AND MODELING

(See Nos. 509, 609)

TECHNIQUES

(Also see Nos. 538, 544)

78-550

Exciter Force Apportioning for Modal Vibration Testing Using Incomplete Excitation

G. Morosow

Ph.D. Thesis, Univ. of Colorado at Boulder, 144 pp (1977)
UM 77-29,953

Key Words: Modal tests, Vibration tests

The objective of this thesis was to evolve an analytical method that will provide correct ratios of shaker forces for a sinusoidal modal vibration test. The approach uses only experimental data and does not depend on any knowledge of the analytical model. This thesis develops an algorithm and applies it to several simple examples to establish its validity and practicality in terms of engineering applications.

78-551

Information Contained in Measurement - More Information from Fewer but Qualitatively Better Data (Informationen durch Messungen - mehr Aussagen durch weniger, aber qualitativ bessere Informationen)

A. Lingener

Technische Hochschule Magdeburg, East Germany, Maschinenbautechnik, 26 (9), pp 394-397 (Sept 1977) 2 figs, 5 refs
(In German)

Key Words: Measurement techniques

Characteristic signals are examined for their ability to be analyzed. The information content of the characteristic signals of a periodic process is represented by a diagram.

COMPONENTS

SHAFTS

(Also see No. 558)

78-552

Torsional Response of Compressor Shaft Systems During Synchronous Motor Startup. Part 1. Analytical Model

G. Mruk, J. Halloran, and R. Kolodziej

Joy Manufacturing Co., Buffalo, NY 14200, ASME Paper No. 77-Pet-49

Key Words: Shafts, Compressor shafts, Vibration response, Mathematical models

This paper presents a mathematical model which is in sufficient detail to predict the shaft torsional response in the case of a motor/compressor unit. The implementation on both analog and digital computers is discussed and results from both implementations compare favorably with field data. The use of the model in addressing torsional response problems is illustrated.

78-553

The Torsional Response of Compressor Shaft Systems During Synchronous Motor Startups. Part II. Field Measurement Techniques

R. Kolodziej, J. Halloran, and G. Mruk

Joy Manufacturing Co., Buffalo, NY 14200, ASME Paper No. 77-Pet-60

Key Words: Shafts, Compressor shafts, Torsional vibration, Measurement techniques, Diagnostic techniques

This paper describes a method for field measurement of the instantaneous value of synchronous motor air gap torque and of system shaft stresses.

78-554

The Torsional Response of Compressor Shaft Systems During Synchronous Motor Startup. Part III. Abnormal Motor Conditions

J.D. Halloran, G. Mruk, and R. Kolodziej

Joy Manufacturing Co., Buffalo, NY 14200, ASME Paper No. 77-Pet-56

Key Words: Shafts, Compressor shafts, Torsional vibration, Diagnostic techniques

Monitoring synchronous motor driven systems for abnormalities is discussed. The aim of the monitoring would be to abort the motor start before shaft torques approached failure level.

BEAMS, STRINGS, RODS, BARS

(Also see Nos. 507, 515, 516. 534. 573, 616)

78-555

Response of Finite Periodic Beams to Convected Loading -- An Approximate Method

U.N. Rao and A.K. Mallik

Dept. of Mech. Engrg., Indian Inst. of Tech., Kanpur-208016, India, J. Sound Vib., 55 (3), pp 395-403 (Dec 8, 1977) 6 figs, 7 refs

Key Words: Beams, Periodic structures

The space-averaged response of a finite, periodic beam on transversely rigid supports and subjected to convected loading has been studied by using an approximate "assumed mode" method. The method has also been shown to yield accurate results for both the real and the imaginary parts of the propagation constant for free wave motion in an infinite periodic beam.

78-556

In-Plane Vibrations of Elliptic Arc Bar and Sinus Curve Bar

S. Takahashi, K. Suzuki, K. Fukazawa, and K. Nakamachi

Yamagata Univ., Yonezawa, Japan, Bull. JSME, 20 (148), pp 1236-1243 (Oct 1977) 10 figs, 5 refs

Key Words: Curved bars, Equations of motion, Natural frequencies

The in-plane vibrations of curved bars are studied. The center line of the bar is arc of an ellipse or of a sinus curve. Two

methods to solve the problems are used. One using a function representing the arc curvature by arc length and the other using a variable which relates to arc length and represents the curvature.

78-557
Vibrations of Segmented Beams by a Fourier Series Component Mode Method
S.C. Mittendorf and R. Greif
Dept. of Mech. Engrg., Tufts Univ., Medford, MA 02155, J. Sound Vib., 55 (3), pp 431-441 (Dec 8, 1977) 6 figs, 4 tables, 10 refs

Key Words: Beams, Component mode analysis, Fourier series, Vibration response

The fundamental nature of the component mode method, based on Fourier series, is examined and applied to a wide variety of non-uniform beam vibration problems. Results are shown for non-uniform beams including the effects of intermediate masses and springs.

BEARINGS

(Also see Nos. 537, 574)

78-558
High Efficiency Fluid Film Thrust Bearings for Turbomachinery
B.S. Herbage
Centritech Corp., Houston, TX, Proc. 6th Turbomachinery Symp., pp 33-38 (Dec 1977) 15 figs, 1 table, 5 refs
Sponsored by Dept. of Mech. Engr., Gas Turbine Labs, Texas A&M Univ., College Station, TX

Key Words: Thrust bearings, Fluid film bearings, Energy absorption

Fluid film thrust bearings in use on high speed high capacity turbomachinery absorb a great amount of energy in performing their task of positioning rotors. Thrust bearing fundamentals are briefly outlined. It is shown how thrust bearing performance can be substantially improved. The major improvements come from selection of materials and methods of lubrication.

78-559
Dynamic Characteristics of Fluid-Film Bearings
W. Shapiro and R. Colsher
Rotor Dynamics and Seals Section, Mech. Engrg. Lab, The Franklin Inst. Research Labs, Philadelphia, PA, Proc. 6th Turbomachinery Symp., pp 39-53 (Dec 1977) 10 figs, 11 tables, 4 refs
Sponsored by Dept. of Mech. Engrg., Gas Turbine Labs, Texas A&M Univ., College Station, TX

Key Words: Fluid-film bearings, Damping coefficients, Spring constants

The concept of cross-coupling in bearings is introduced and its influence on bearing dynamics is presented. Procedures for obtaining cross-coupled spring and damping coefficients are explained. The special case of pad pitch coupling in tilting-pad bearings is discussed and the method, assumptions and equations made in reducing the complete tilting pad matrix to the more conventional 4 X 4 is presented. The closed form solutions for point mass bearing whirl utilizing the cross-coupled coefficients is developed in the discussion of bearing stability. Discussions of various bearing types with recommended geometric considerations are presented. Data on steady-state performance; cross-coupled coefficients and whirl stability of various bearing types are included.

BLADES

(Also see No. 515)

78-560
Effect of Centrifugal Forces on Lateral Deflection and Fundamental Frequency of Turbine Blade
G. Zuladzinski
Los Alamitos, CA, ASME Paper No. 77-Pet-12

Key Words: Turbine blades, Rotatory inertia effects

The well-known fact that centrifugal forces reduce the effect of lateral loading on a blade is demonstrated here using work-energy formulation. A reduction factor similar to that for elementary cases of beam-columns is sought. The findings are verified by numerical analysis of a finite-element model of a blade. A meaningful form of a factor relating the fundamental frequencies of a rotating and a stationary blade is developed.

CYLINDERS

78-561
Free Vibration of Clusters of Cylinders in Liquid-Filled Channels
M.P. Paidoussis, S. Suss, and M. Pustejovsky

Dept. of Mech. Engrg., McGill Univ., Montreal, Quebec H3A 2K6, Canada, J. Sound Vib., 55 (3), pp 443-459 (Dec 8, 1977) 6 figs, 1 table, 8 refs

Key Words: Cylinders, Submerged structures, Fluid-induced excitation, Eigenvalue problems, Heat exchangers

This paper presents two methods for the calculation of the virtual masses of clusters of parallel cylinders in liquid contained by an outer channel. The first method is based on classical potential flow theory, and its applicability is limited to circular cylinders in circular cylindrical channels; the second, using fluid finite elements, may be applied to more general geometries. Illustrative examples compare the two methods.

DUCTS

(See No. 525)

FRAMES, ARCHES

78-562

GITRA - A Graphic Interactive Computer Program for Designing Framed Structures (GITRA - ein grafisches interaktives Programmsystem zur Tragsystemkonstruktion)

C.-D. Wolf and A. Keil

Technische Hochschule Karl-Marx-Stadt, Sektion Maschinen-Bauelemente, East Germany, Maschinenbautechnik, 26 (9), pp 423-426 (Sept 1977) 7 figs, 18 refs

(In German)

Key Words: Framed structures, Computer programs, Computer-aided techniques, Design techniques

The computer program GITRA, employing modern mathematical-mechanical methods, is designed to investigate static and dynamic behavior of plane and space frames. A graphic interactive display device is utilized. The concept and strategy of the GITRA computer program enables the designer to produce any desired number of designs by varying the parameters of the structure and elements and permits him to test their mechanical behavior.

78-563

An Accurate Method in Structural Vibration Analysis

T.H. Richards and Y.T. Leung

Dept. of Mech. Engrg., Univ. of Aston in Birmingham, B4 7ET, UK, J. Sound Vib., 55 (3), pp 363-376 (Dec 8, 1977) 5 figs, 3 tables, 10 refs

Key Words: Framed structures, Natural frequencies, Mode shapes, Matrix methods, Dynamic stiffness, Mass matrices

An important element in the dynamic analysis of structures is the computation of their natural frequencies and modes. For complex systems, this inevitably requires automatic computation so that an accurate and reliable algorithm is essential. In this paper, a method in which subspace iteration is utilized in conjunction with a frequency dependent mass and stiffness formulation is described and applied to framed structures.

GEARS

78-564

High Ratio Gears (Hochübersetzende Getriebe)

R. Neumann

Technische Universität Dresden, Maschinenbautechnik, 26 (7), pp 297-300, 305 (July 1977) 19 figs, 18 refs

(In German)

Key Words: Gears

Construction and application of high ratio gears, based on the principle of hypocyclic drive, are described. They are particularly suitable where space, mass, vibration, and mounting play a significant role.

78-565

Statistical Analysis of Dynamic Loads on Spur Gear Teeth (Experimental Study)

T. Tobe, K. Sato, and N. Takatsu

Tohoku Univ., Sendai, Japan, Bull. JSME, 20 (148), pp 1315-1320 (Oct 1977) 14 figs, 5 refs

Key Words: Gears, Statistical analysis, Experimental data

Some experimental results on the relation between transmission errors and dynamic loads of spur gears are presented. Using a power circulating type gear tester, the dynamic loads on two pairs of gears, i.e. an accurate one and a rough one, were measured and their dependence on gear speed and tooth load was investigated.

78-566

High Speed Gears -- Design and Application

J.R. Partridge

Gear Div., Lufkin Industries, Inc., Lufkin, TX, Proc. 6th Turbomachinery Symp., pp 133-142 (Dec 1977) 7 figs
Sponsored by Dept. of Mech. Engrg., Gas Turbine Labs., Texas A&M Univ., College Station, TX

Key Words: Gears, Design techniques

High speed gear drives can be reliable if all the factors influencing their design, application, and operation are considered during the design stages. This paper discussed the parameters used by gear engineers and the influence of design variations. The design is analyzed from gear tooth geometry to installation considerations. Manufacturing processes, lubrication, allowable vibration levels, along with a simple gear comparison method are described.

78-567
High-Speed Gear Vibration and Noise Experience
N.E. Bruce
Shell Oil Co., Wood River, IL., Proc. 6th Turbomachinery Symp., pp 85-90 (Dec 1977) 8 figs
Sponsored by Dept. of Mech. Engrg., Gas Turbine Labs., Texas A&M Univ., College Station, TX

Key Words: Gears, Noise generation

High-speed gear pinion precession-shuttling and noise, caused by overhanging weight of the coupling and by misalignment forces generated by tooth friction in the coupling, are being controlled by reduced bearing clearances. A statistical analysis of high-speed gear, mesh-frequency, vibrations was used to decide that sleeve bearings would not control the precession-shuttling adequately and that use of tilting-shoe radial bearings was necessary.

78-568
Gear Noise Spectra -- A Rational Explanation
D.B. Welbourn
Univ. of Cambridge, UK, ASME Paper No. 77-DET-38

Key Words: Gears, Noise generation, Design techniques

This paper gives a critical assessment of the knowledge of the relationship between noise, design variables, and manufacturing errors in gears. A rational physical explanation is given which unifies most of the published experimental work, as well as some unpublished work presented here.

LINKAGES
(Also see No. 511)

78-569
Dynamic Analysis of Assembled Structures (Analyse Dynamique des Structures Assemblees)
M. Lalanne, D. Ewins, and J. DerHagopian
85 pp (May 1976)
(In French)
N77-32535

Key Words: Linkages, Natural frequencies, Damping, Measuring instruments

The various types of linking devices between assembled structures and their dynamic effects were studied. An experimental measuring device was built to precisely record the variations of the dynamic properties, especially frequencies and damping. A method of measurement based on impedance and Nyquist graphs was devised together with a computation method of the structures using the finite element method. Tests of the equipment were performed and the methodology is detailed.

PANELS

78-570
Dynamic Responses of Circular Cylindrical Shells Having Finite Lengths Subjected to Concentrated Impulsive Loads
S. Ujihashi, M. Kodaira, H. Matsumoto, and I. Nakahara
Tokyo Inst. of Technology, 2-12-1, Ookayama, Meguro-ku, Tokyo, Japan, Bull. JSME, 20 (148), pp 1228-1235 (Oct 1977) 13 figs, 14 refs

Key Words: Cylindrical shells, Circular shells, Dynamic response, Rotatory inertia effects, Donnell theory

In this paper, the dynamic displacements and stresses in circular cylindrical shells having finite lengths with both ends free and both ends clamped, which are suddenly subjected to equal and opposite radial concentrated loads, are analytically investigated on the basis of Donnell's shell equations including the effect of radial inertia force.

78-571
Ambient Temperature Fatigue Tests of Elements of an Actively Cooled Honeycomb Sandwich Structural Panel

E.L. Sharpe and W. Elber
Langley Res. Center, NASA, Langley Station, VA, Rept. No. NASA-TM-X-3557; L-11552, 27 pp (Sept 1977)
N77-32537

Key Words: Sandwich structures, Honeycomb structures, Panels, Aircraft, Structural elements, Fatigue tests

Elements of an actively cooled structural panel for a hypersonic aircraft have been investigated for fatigue characteristics. The study involved a bonded honeycomb sandwich panel with d-shaped coolant tubes. The curved portion of these tubes was embedded in the honeycomb, and the flat portion was bonded or soldered to the inner surface of the outer skin. The elements examined were two plain skin specimens (aluminum alloy); two specimens with skins attached to manifolds and tubes (one specimen was bonded, the other soldered); and a specimen representative of a corner section of the complete cooled sandwich. Sinusoidal loads were applied to all specimens. The honeycomb sandwich specimen was loaded in both tension and compression; the other specimens were loaded in tension only. The cooling tubes were pressurized with oil throughout the fatigue tests.

PIPES AND TUBES

78-572

A Distributed Parameter Mathematical Model of a Vertical U-Tube Steam Generator

R.S. Dumont
Ph.D. Thesis, The Univ. of Saskatchewan (Canada) (1977) Dissertation Abstracts International, B., p 3440 (Jan 1978)

Key Words: Boilers, Mathematical models, Continuous parameter method, Tubes, Shells

This thesis presents the development and testing of a dynamic distributed parameter mathematical model of a vertical U-tube steam generator of the type used in the Canadian Deuterium Uranium-Pressurized Heavy Water System. Special features of the model include a finite difference scheme for integration of the partial differential equations, condensing flow on the tube side of the boiler, and non-equilibrium states for the steam drum fluid.

78-573

Short Time Dynamic Elastic-Plastic Response of a Beam Due to a Time Varying Transverse Load with Application to Pipe Whip

R.F. Cooke
Outboard Marine Corp., Milwaukee, WI, ASME Paper No. 77-PVP-56

Key Words: Beams, Pipes, Elastoplastic properties, Flexural vibration

The method of Duwez is reviewed as it applies to the impact of a pipe on a rigid restraint. The method is then generalized to study the response due to a time varying transverse load applied to the end of a semi-infinite pipe. This simulates the response due to a rupture force.

PLATES AND SHELLS

(Also see Nos. 507, 593)

78-574

The Application of a Semi-Actuator Disk Model to Sound Transmission Calculations in Turbomachinery. Part II: Multiple Blade Rows

R.S. Muir
Structural Dynamics Ltd., 18 Carlton Crescent, Southampton S01 2ET, UK, J. Sound Vib., 55 (3), pp 335-349 (Dec 8, 1977) 6 figs, 1 table, 3 refs

Key Words: Disks, Turbomachinery, Blades, Sound transmission

The work described in this paper extends the application of a semi-actuator disk model to the transmission of sound in multiple blade rows. The blade rows may be rotating or stationary, the basic element comprising a pair of blades in a rotor-stator configuration. The rows are coupled by reflected acoustic waves and shed vorticity interactions, leading to a sound regeneration mechanism between each pair of blades.

78-575

The Nonlinear Response and Stability of Rotating Shells

J.W. Klahs
Ph.D. Thesis, Purdue Univ., 224 pp (1976)
UM 77-30,094

Key Words: Dynamic stability, Shells, Plates, Rotating structures

This research is an investigation of the dynamic response and stability of thin structures undergoing an enforced general space motion. This motion gives rise to dynamic inertial loading that, in turn, induces a vibratory structural response. Because the enforced nature of the motion implies an unlimited supply of energy, it is possible for such systems to lose dynamic stability.

78-576

Flexural Vibrations of Finite Cylindrical Shells of Various Wall Thicknesses - I

J. Chandra and R. Kumar

Systems Engrg. Div., Defence Science Lab., Metcalfe House, Delhi-11054, India, Acustica, 38 (4), pp 258-263 (Oct 1977)

Key Words: Cylindrical shells, Variable cross section, Flexural vibration

In this paper, the frequency-aspect ratio curves have been obtained for the flexural vibrations of finite, isotropic, cylindrical shells of various wall thicknesses, having symmetric motion about their central plane. The stress-free boundary conditions on the lateral surfaces of the shells are satisfied exactly; whereas the stress-free boundary conditions on the flat surfaces of the shells are satisfied to a good degree of approximation. In order to show the validity of the theory, the residual stresses at the flat ends of the shells have been given for some random cases. For these random cases, the displacement patterns have also been given.

78-577

Normal Mode Solution of Fluid Coupled Concentric Cylindrical Vessels

W.J. Stokey and R.J. Scavuzzo

Carnegie-Mellon Univ., Pittsburgh, PA, ASME Paper No. 77-PVP-37

Key Words: Cylindrical shells, Fluid-induced excitation, Normal modes

A normal mode solution is developed for concentric cylinders coupled by fluid between them and subjected to foundation input motion. Both time-history and spectral inputs can be specified. Example problems are presented.

78-578

Response of a Fluid-Filled Cylindrical Shell to a Moving Load

S. Chonan

Dept. of Mech. Engrg., Tohoku Univ., Sendai, Japan, J. Sound Vib., 55 (3), pp 419-430 (Dec 8, 1977) 10 figs, 1 table, 6 refs

Key Words: Cylindrical shells, Fluid-filled containers, Rotatory inertia effects, Transverse shear deformation effects, Moving loads

This paper presents a theoretical analysis of the axisymmetric response of an infinitely long, circular, cylindrical shell which is filled with a compressible fluid medium and is subjected to a ring load traveling axially at a constant speed. The solution is derived by using shell theory, which includes the effects of rotary inertia and shear deformations. Numerical results are presented for the case of steel shells filled with water.

78-579

An Investigation into Nonlinear Vibrations of Thin Plates

C.P. Vendhan

Dept. of Civil Engrg., Univ. of Massachusetts, Amherst, MA 01003, Intl. J. Nonlinear Mech., 12 (5), pp 209-221 (1977) 5 figs, 2 tables, 12 refs

Key Words: Plates, Nonlinear theories

The variational and modified forms of the von Karman-type non-linear plate equations are considered in the context of the Rayleigh-Ritz and Galerkin methods. An approximate analysis of the non-linear vibrations of thin elastic plates including inplane inertia is presented.

78-580

Dynamic and Nonlinear Analysis of Shells of Revolution

P.K. Basu

Ph.D. Thesis, Washington Univ., 447 pp (1977) UM 77-28,338

Key Words: Plates, Shells of revolution, Cooling towers, Wind-induced excitation, Computer programs

Nonlinear strain-displacement relationships are derived for the case of thin to moderately thick shells of arbitrary shape and varying thickness starting with the strain tensor in Lagrangian coordinates for a three dimensional continuum. The derivation includes the effect of transverse shear strains. Various special cases for both plates and shells, including the axisymmetric ones, are also considered. A user oriented computer software, named SHORE-III, is developed for linear static and dynamic analysis of axisymmetric shells and plates by the finite element displacement method. The static, free vibration, and time history analysis of a large number of various kinds of shells are carried out, and the accuracy and convergence characteristics of the solutions are evaluated. Moreover, the time history response of three prototype hyperbolic cooling towers under measured wind loads is investigated in detail.

78-581
Forced Motion of an Initially Stressed Rectangular Plate -- An Elasticity Solution
H. Reismann and H.-H. Liu
Dept. of Engrg. Science, Aerospace Engrg. and Nuclear Engrg., State Univ. of New York, Buffalo, NY 14214, J. Sound Vib., 55 (3), pp 405-418 (Dec 8, 1977) 9 figs, 1 table, 6 refs

Key Words: Rectangular plates, Forced vibration, Elastic analysis

An initially stressed rectangular plate is subjected to a transverse, time dependent load. The initial stress field is constant and parallel to two of the plate edges. The transverse load is uniformly distributed over a rectangular area, the sides of which are parallel to the sides of the plate. The problem is formulated within the framework of classical, three-dimensional elasticity theory, and an exact solution is obtained in series form. The case of static stability under prestress is also considered.

78-582
A Note on the Determination of the Fundamental Frequency of Vibration of Thin, Rectangular Plates with Edges Possessing Different Rotational Flexibility Coefficients
P.A.A. Laura, L.E. Luisoni, and C. Filipich
Inst. of Applied Mechanics, Base Naval Puerto Belgrano, 8111 Argentina, J. Sound Vib., 55 (3), pp 327-333 (Dec 8, 1977) 3 figs, 3 tables, 8 refs

Key Words: Rectangular plates, Fundamental frequency

This problem is solved by using a simple polynomial expression which identically satisfies the boundary conditions. A variational formulation is then applied and an approximate but extremely accurate and simple frequency equation is generated.

78-583
Finite Amplitude Vibrations of a Circular Plate
C.L.D. Huang and I.M. Al-Khattat
Dept. of Mech. Engrg., Kansas State Univ., Manhattan, KS 66506, Intl. J. Nonlinear Mech., 12 (5), pp 297-306 (1977) 7 figs, 8 refs

Key Words: Circular plates, Vibration response, Boundary value problems

The problem of finite amplitude, axisymmetric free and forced vibration of a circular plate is examined with various boundary conditions.

78-584
Stability of Stationary and Rotating Discs Under Edge Load
C.J. Radcliffe and C.D. Mote, Jr.
Dept. of Mech. Engrg. and Forest Products Lab., Univ. of California, Berkeley, CA 94720, Intl. J. Mech. Sci., 19 (10), pp 567-574 (1977) 8 figs, 1 table, 13 refs

Key Words: Disks, Circular plates, Critical speed

The dominant dynamic instability mechanism in circular cutters, grinding wheels and the like is a moving load resonance excited by a constant transverse load at the "critical rotation speed." The critical speed theory is extended here to include the effects of concentrated in-plane edge loads similar to loading occurring in engineering processes. These analyses are confirmed through prediction and measurement of static buckling loads for centrally clamped discs with in-plane, concentrated loads inclined between 0° and 80° to the edge normal.

SPRINGS

78-585
Vibration of Helical Springs (Schwingungen zylindrischer Schraubenfedern)
F. Wahl
Technische Hochschule Otto v. Guericke, Magdeburg, Maschinenbautechnik, 26 (8), pp 369-370, 374 (Aug 1977) 4 figs, 9 refs
(In German)

Key Words: Helical springs, Longitudinal vibration, Torsional vibration, Flexural vibration

The vibrations of helical springs, based on the theory of spatial curved bar, were investigated. The results are used to evaluate the accuracy of the usual calculation methods of longitudinal, torsional, and flexural vibrations.

TIRES

78-586
Quiet Tires: Safety and Economic Considerations
W.A. Leasure, Jr.
Office of Noise Abatement, U.S. Dept. of Transportation, Washington, D.C. 20590, Proc. Nat'l. Conf. on Noise Control Engrg., pp 117-128 (1977)

Key Words: Tire characteristics, Noise reduction

This paper discusses the cost and safety implications of the various alternatives to current tire use practice that could be implemented to reduce noise.

SYSTEMS

ABSORBER

78-587

Design of a Metal Skinning Energy Absorber for the U.S. Capitol Subway System

J.A. Kirk

Dept. of Mech. Engrg., Univ. of Maryland, College Park, MD 20742, Intl. J. Mech. Sci., 19 (10), pp 595-602 (1977) 6 figs, 4 tables, 7 refs

Key Words: Energy absorbers, Subway railways, Collision research (railroad)

The design of a metal skinning emergency overshoot stopping device is discussed. The kinetic energy of the vehicle is dissipated by pulling a round rod through a circular cutting tool. Photographs of the final design hardware are shown. A subway collision test was conducted and the results of the test are shown to agree well with predictions.

78-588

An Improved Vehicular Impact Absorption System

A.C. Knoell and A.N. Wilson

NASA, Pasedena, CA, PAT-APPL-826 204/GA, 11 pp (Aug 19, 1977)

Key Words: Energy absorption, Shock absorbers, Collision research (automotive)

An improved vehicular impact absorption system is reported that uses aligned crash cushions of substantially cubic configurations. Each consists of voided aluminum beverage cans arranged in superimposed tiers and a covering envelope formed of metal hardware cloth. A plurality of cables extends through the cushions in substantial parallelism with an axis of alignment for the cushions to be anchored at each of the opposite ends.

NOISE REDUCTION

78-589

A Computerized Hot-Wire Investigation of the Stability of Separated Shear Layers with Application to Ship Silencing

D.M. Schubert

Naval Academy, Annapolis, MD, Rept. No. USNA-TSPR-89, 90 pp (May 23, 1977)

AD-A045 377/9GA

Key Words: Ship noise, Noise reduction, Fluid-induced excitation

This study was made on the stability of a two-dimensional air jet applicable to ship noise silencing.

ACTIVE ISOLATION

(See No. 595)

AIRCRAFT

(Also see Nos. 521, 522, 523, 524)

78-590

Application of System Identification to Analytic Rotor Modeling from Simulated and Wind Tunnel Dynamic Test Data

D. Banerjee

Ph.D. Thesis, Washington Univ., 202 pp (1977)

UM 77-28,337

Key Words: Aircraft, System identification technique, Rotors, Rotary wings

A simplified form of the Maximum Likelihood method is selected to extract analytical aeroelastic rotor models from simulated and dynamic wind tunnel test results for accelerated cyclic pitch stirring excitation. The goal is to determine the dynamic inflow characteristics for forward flight conditions from the blade flapping responses without direct inflow measurements.

78-591

Recent Advances in Aerodynamic Energy Concept for Flutter Suppression and Gust Alleviation Using Active Controls

E. Nissim

Langley Res. Center, NASA, Langley Station, VA,

Rept. No. NASA-TN-D8519; L-11707, 67 pp (Sept 1977)
N77-32536

Key Words: Aircraft, Flutter, Wind induced excitation

Control laws are derived, by using realizable transfer functions, which permit relaxation of the stability requirements of the aerodynamic energy concept.

BIOENGINEERING

(See No. 593)

BRIDGES

(Also see No. 530)

78-592
Experimental Study of the Dynamic Response of Highway Bridges
P.K. Kropp
Ph.D. Thesis, Purdue Univ., 310 pp (1977)
UM 77-30,098

Key Words: Bridges, Traffic-induced vibrations, Experimental data

The objective of this investigation was to establish the basic response characteristics for common types of highway bridges under the passage of ordinary vehicular traffic. The response characteristics under consideration were the maximum values of displacement, velocity, acceleration, and jerk together with the frequency content and damping ratio. Sixty-two bridges of all types of construction with one through four spans were instrumented with a deflection gage and a varying number of accelerometers. More than 2200 vehicle crossings were recorded with the major portion being heavy trucks.

BUILDING

(See No. 518)

FOUNDATIONS AND EARTH

(See No. 622)

HUMAN

78-593
Effect of Pulse Loading on Brain Injury
J.C. Misra, C. Hartung, and O. Mahrenholtz
Indian Inst. of Tech., Karagpur, India, Mech. Res. and Comm., 4 (5), pp 297-302 (1977) 9 figs, 7 refs

Key Words: Human head, Mathematical models, Spherical shells, Pulse excitation

The effect of pulse loading on a human-sized, head shaped object was investigated. Four pulse shapes, square, half-sine, triangular, and skewed were considered. The skull was modeled as a thick prolate spheroidal shell of viscoelastic solid and the brain as a viscoelastic fluid.

ISOLATION

78-594
Liquid-Spring Shock Isolator Modeling
P.N. Sonnenburg, B.H. Wendler, and W.E. Fisher
Construction Engrg. Research Lab (Army), Champaign, IL, Rept. No. CERL-TR-M-226, 57 pp (Sept 1977)
AD-A044 993/4GA

Key Words: Shock isolators, Mathematical models, System identification technique

The purpose of this pilot study was to determine whether mathematical models of high-performance shock isolators could be established from test performance data. A liquid spring was modeled using an open-parameter differential equation. A system identification technique was used to select the best algebraic form of the model and to optimize the parameters for the sample isolator.

MECHANICAL

(See Nos. 512, 517, 518)

METAL WORKING AND FORMING

78-595
Design of Servodamper Control System
N. Tanaka, N. Suzuki, Y. Iwata, A. Kanai, and M. Miyashita

Tokyo Metropolitan Univ., Setagaya-ku, Tokyo, Japan, Bull. JSME, 20 (148), pp 1269-1276 (Oct 1977) 18 figs, 9 refs

Key Words: Active dampers, Servo mechanisms, Machine tools, Chatter

For the purpose of increasing the dynamic stiffness of mechanical structures, this paper proposes a servodamper method. The servodamper can be applied even to structures whose dynamic characteristics vary in a very large frequency range. From a viewpoint of state feedback control, a design procedure of the servodamper system is shown. Then proposing a new concept of a minimum performance index, this paper presents a criterion to determine a control law for the servodamper control system. Using the criterion defined in this paper, a damping effect on structures is discussed quantitatively. Finally, experimental results of the servodamper system are reported.

78-596

Stability Analysis of Cylindrical Grinding under the Effect of Workpiece Shape

S. Shiozaki, Y. Furukawa, and T. Ogawa

Dept. of Mech. Engrg., Tokyo Metropolitan Univ., Setagaya-ku, Tokyo, Japan, Bull. JSME, 20 (148), pp 1321-1328 (Oct 1977) 15 figs, 2 tables, 7 refs

Key Words: Machine tools, Chatter

A new stability equation for self-excited chatter considering the effects of the workpiece and its support structure is given. Experimental validation is provided.

78-597

Derivation of Chatter Criterion During the Grinding Process (Erarbeitung eines Ratterkriteriums für den Schleifprozess)

R. Piegert and J. Pickert

Technische Hochschule Karl-Marx-Stadt, Sektion Fertigungsprozess und- mittel, East Germany, Maschinenbautechnik, 26 (9), pp 397-402 (Sept 1977) 7 figs, 1 table

(In German)

Key Words: Machining, Chatter

The authors develop typical characteristic quantities for the grinding process from which reproducible and process-dependent machine life and chatter critieron may be derived. The process is a means of automatic control.

78-598

Reasons for Self Excited Vibrations During Machining (Ursachen zur Entstehung selbsterregter Schwingungen bei der spanenden Bearbeitung)

S. Recklies

Technische Universität Dresden, Sektion Fertigungstechnik und Werkzeugmaschinen, Maschinenbautechnik, 26 (9), pp 403-407 (Sept 1977) 5 figs, 12 refs

(In German)

Key Words: Machine tools, Self-excited vibrations

The authors show that of all the known causes for the generation of self-excited vibrations of machine tools only the position coupling satisfies all conditions for a pure self-excited mechanism. In addition, for the modeling of an automatic control process of the cutting procedure, at least a double-loop system is needed, which holds especially for multipoint tools.

78-599

Investigation of the Milling Machine FYD-25 (Untersuchung der Stabilität der Fräsmaschine FYD-25)

W. Lisewski

Institut f. Maschinenbau an der Technischen Hochschule Szczecin, Poland, Maschinenbautechnik, 26 (9), pp 408-409, 418 (Sept 1977) 5 figs, 6 refs

Key Words: Machine tools, Cutting, Stability

The stability of a cutting process, without reducing production of the machine, can be achieved by changing the speed of the machine tool. A meaningful change can be obtained only if the characteristic which gives the stability limit independently of cutting depth and spindle speed can be found. The object of this paper is to find such a characteristic for given operating conditions for the milling machine FYD-25.

78-600

Machine Tool Vibrations (Schwingungen an Werkzeugmaschinen)

H. Aurich

Technische Hochschule Karl-Marx-Stadt, Sektion Verarbeitungstechnik, East Germany, Maschinenbautechnik, 26 (9), pp 413-418 (Sept 1977) 8 figs, 3 tables, 26 refs

(In German)

Key Words: Machine tools, Vibration response, Computer programs

Results of research on vibrations of machine tools, performed between 1970-1976 are presented. By means of improved Hermite deformation expressions the finite element theory of beams is further developed. The basis for the creation of program system RASTADYN was created. Modeling problems and various element types are described. It is possible to build minimum models by means of matrix condensation. The program GITRA, which is a further development of RASTADYN, facilitates a graphic data processing by means of an active display device.

78-601

Application of the Rigid Finite Element Method for the Determination of Dynamic Characteristics of the Milling Machine (FWD-25U) Beam (Anwendung der Methode starrer finiter Elemente zur Bestimmung der dynamischen Charakteristiken des Balkens der Fräsmachine FWD-25U)

A. Witek

Institut f. Maschinenbau an der Technischen Hochschule Szczecin, Poland, Maschinenbautechnik, 26 (9), pp 410-412 (Sept 1977) 4 figs, 8 refs

(In German)

Key Words: Machine tools, Mathematical modeling, Rigid finite element technique

The rigid finite element method can be used for the modeling and calculation of weak nonlinear systems. They can be linearized without affecting the accuracy of results. Many machine tool groups satisfy this requirement, so that the rigid finite element method can be effectively applied in the design of machine tools. Preparation of data for the rigid element method is much less time consuming and smaller computers can be used than for the finite element technique.

PUMPS, TURBINES, FANS COMPRESSORS

(Also see Nos. 617, 618)

78-602

An Analysis of the Influence of Some External Disturbances on the Aerodynamic Stability of Turbine Engine Axial Flow Fans and Compressors

W.F. Kimzey

Ph.D. Thesis, The Univ. of Tennessee, 287 pp (1977)

UM 77-27,675

Key Words: Turbine engines, Mathematical models, Fans, Compressors, Aerodynamic stability

The overall objective of the work was to develop an improved method for the computation of the influence of external disturbances on turbine engine compressor stability. A one-dimensional, time-dependent mathematical compressor model for analysis of planar disturbances was developed and extended to a three-dimensional form for analysis of distorted inflows. Three different compressors were analyzed using the models.

78-603

Compressor Drive Turbines of High Efficiency and Great Operational Safety

K. Körner

Steam Turbine Dept., AEG-KANIS Turbinenfabrik GmbH Nürnberg, Germany, Proc. 6th Turbomachinery Symp., pp 75-83 (Dec 1977) 24 figs

Sponsored by Dept. of Mech. Engrg., Gas Turbine Labs., Texas A&M Univ., College Station, TX

Key Words: Steam turbines, Blades, Shafts

The problems described in this paper, confronting a turbine designer, are blade and shaft vibrations, bending and centrifugal stresses, torsional analyses as well as optimal designing with respect to the requirement of attaining high efficiencies. Solutions to these problems arising from new technology are listed.

78-604

Inlet Turbulence and Fan Noise Measured in an Anechoic Wind Tunnel and Statically with an Inlet Flow Control Device

L.M. Shaw, R.P. Woodward, F.W. Glaser, and B.J. Dastoli

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-73723; E-9273, 28 pp (Oct 1977)

Sponsored by AIAA

N77-32836

Key Words: Fans, Noise measurement, Wind tunnel tests

Turbulence and acoustic measurements were taken in a wind tunnel which has demonstrated blade passage tone cutoff phenomena with forward velocity. Turbulence data were taken in a subsonic inlet at various fan speeds under static and forward velocity conditions. A honeycomb/screen flow control device was placed over the inlet during static tests to modify the inflow in an attempt to simulate flight conditions. Acoustic levels of the blade passage tone along with transverse turbulence intensities were reduced with forward velocity.

78-605

Summary of Forward Velocity Effects on Fan Noise

C.E. Feiler and J.F. Groeneweg

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-73722; E-9209, 16 pp (Oct 1977)

Sponsored by AIAA

N77-32159

Key Words: Fans, Noise source identification, Noise reduction

Available experimental data comparing the in-flight and static behavior of fan noise are reviewed. These results are then compared with recent data obtained for a fan stage tested with forward velocity in a low speed wind tunnel. Tentative conclusions are presented about the significance and nature of the changes in noise observed when a forward velocity is imposed. Finally, the implications of the emerging picture of in-flight fan source noise for suppressor design are discussed.

78-606

Acoustic Performance of Inlet Multiple-Pure-Tone Suppressors Installed on NASA Quiet Engine C

H.E. Bloomer, J.W. Schaefer, E.J. Rice, and C.E. Feiler

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-73713, 16 pp (Oct 1977)

Sponsored by AIAA

N77-32158

Key Words: Fans, Noise reduction

The length of multiple-pure-tone treatment required to reasonably suppress effects produced by a supersonic tip speed fan was defined. Other suppression, broadband, and blade passing frequency, which might be accomplished were also determined. The experimental results are presented in terms of both far-field and duct acoustic data.

78-607

Dynamic Simulation of Centrifugal Compressor Systems

R.A. Stanley and W.R. Bohannan

Bechtel, Inc., San Francisco, CA., Proc. 6th Turbomachinery Symp., pp 123-131 (Dec 1977) 11 figs, 8 refs

Sponsored by Dept. of Mech. Engrg., Gas Turbine Labs, Texas A&M Univ., College Station, TX

Key Words: Turbomachinery, Rotary compressors, Simulation, Mathematical models

This paper discusses the application of dynamic simulation to centrifugal compressor control system design. Three complex compressor systems which have been designed with the aid of simulation are presented. Two of the compressors are refrigeration units installed in a liquified natural gas plant. The third is a high pressure gas injection compressor. Each of the units consumes power in the range of 25,000 to 40,000 BHP. The procedures followed in developing the simulation models are outlined. The structure of the mathematical models and the method of solution of the models are discussed.

78-608

Vibrations in Very High Pressure Centrifugal Compressors

P.L. Ferrara

Nuovo Pignone, Florence, Italy, ASME Paper No. 77-DET-15

Key Words: Compressors, Aerodynamic excitation, Vibration response, Experimental data

One of the typical problems found in high-pressure centrifugal compressors is the appearance of vibrations related to excitations of aerodynamic origin. This paper presents the results of tests carried out on two high-pressure compressors. It shows the vibration and pressure pulsation patterns recorded with different hydrocarbon mixtures and inert gases up to 10,000 psi pressure under all possible operating conditions, including surge.

78-609

Evaluation of Scale-Model Methods for Operability Qualification of Seismic Category I Pumps and Valves

G.C. Kao, H.H. Yen, and K.Y. Chang

Sargent & Lundy, Chicago, IL, ASME Paper No. 77-PVP-58

Key Words: Pumps, Valves, Seismic response, Model testing

A study was conducted to evaluate the feasibility of employing scale-model testing approaches for use in operability qualification of seismic Category I pumps and valves. The scope of the study included: a literature search to determine existing technology on scale-model testing, the evaluation of critical operability parameters, the evaluation of scaling laws applicable to operability testing, and associated manufacturing and testing costs.

RAIL

(Also see No. 587)

78-610
On the Prediction of Wayside Noise Levels for High-Speed Railway Vehicles
W.F. King, III
Inst. f. Turbulenzforschung, Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Berlin, West Germany, Rept. No. DLR-1B-257-77/6, 45 pp (1976)
N77-32846

Key Words: High speed transportation systems, Rail transportation, Noise prediction

The relative contributions of aerodynamic and wheel/rail noise to railway wayside noise levels are not well understood. Methods for predicting these contributions discussed in this paper include an equation for turbulent boundary layer noise (the minimum wayside noise), an empirical formula for total aerodynamic noise based on airframe noise studies, and the Peters equation for wheel/rail interaction noise. Comparisons are made between predicted and measured noise levels for a buoyant vehicle.

78-611
Computational Methods to Predict Railcar Response to Track Cross-Level Variations
B.E. Platin, J.J. Beaman, J.K. Hedrick, and D.N. Wormley
Dept. of Mech. Engrg., Massachusetts Inst. of Tech., Cambridge, MA., Rept. No. DOT-TSC-FRA-76-13, FRA/ORD-76/293, 86 pp (Sept 1976)
PB-272 676/8GA

Key Words: Freight cars, Interaction: rail-wheel, Digital simulation

The rocking response of railroad freight cars to track cross-level variations is studied using a reduced complexity digital simulation model, and a quasi-linear describing function analysis. The reduced complexity digital simulation model employs a rail truck model that neglects the high-frequency dynamics of the bolster and wheelset masses, yet includes kinematic center plate, side bearings, and wheelset nonlinear effects.

78-612
Development of Advanced Concepts for Noise Reduction in Tracked Vehicles
T.R. Norris, R.B. Hare, A.G. Galaitsis, and G.R. Garinther
Ordnance Engrg. Div., FMC Corp., San Jose, CA., Rept. No. FMC-TR-3162, HEL-TM-25-77, 81 pp (Aug 1977)
AD-A045 679/8GA

Key Words: Tracked vehicles, Noise reduction, Noise source identification

This investigation develops an understanding of the noise sources, the acoustical and vibratory paths through which energy enters the hull structure, and the mechanism by which noise arrives at personnel locations. A theoretical and experimental analysis of primary noise source of the vehicle, i.e., the track and suspension system, consisted of three phases: The design of a computer program to simulate the track and suspension; The isolation of the noise produced by the sprocket, idler and roadwheels to determine the contribution of each of these sources; and The measurement of vibration levels at the suspension system, and force-to-noise transfer functions for predicting interior noise levels.

RECIPROCATING MACHINE

78-613
Mechanically Induced Noise and Vibration in the Automotive Diesel Engine
S.D. Haddad
The Univ. of Technology, Loughborough, Leicestershire, UK, ASME Paper No. 77-DET-37

Key Words: Diesel engines, Engine noise, Engine vibration

Increased use to turbocharging and optimization of the combustion chamber parameters in present and future automotive diesel engines tends to accentuate the mechanical sources of excitation. These sources mainly consist of piston slap, timing gear rattle, bearing impacts, fuel injection operation, valve system and accessories. This paper discusses the other mechanical sources together with their experimental identification and some control methods and shows how these sources can become significant in future low-noise engines.

ROAD

78-614
Invariant Properties of Flexible Highway Pavements
G.Y. Baladi
Ph.D. Thesis, Purdue Univ., 359 pp (1977)
UM 77-30,053

Key Words: Pavements, Traffic induced vibrations

Time dependent transfer (TDT) functions were employed to predict a pavement system's response and performance when subjected to an imposed load. This investigation was carried out by extending transfer function theory in connection with a finite convolution procedure to define the pavement's TDT functions. Full scale dynamic tests (moving trucks and aircraft) were performed in service environments (6 highway and 2 runway cross-sections).

ROTORS

78-615

Unsteady Hovering Wake Parameters Identified from Dynamic Model Tests

S.T. Crews

Ph.D. Thesis, Washington Univ., 123 pp (1977)

UM 77-28,339

Key Words: Rotors, Rotor blades, Parameter identification technique

A 4-bladed model rotor is described which can be excited with a simple eccentric mechanism in progressing and regressing modes with either harmonic or transient inputs. Parameter identification methods were applied to the problem of extracting parameters for linear perturbation models, including rotor dynamic inflow effects, from the measured blade flapping responses to transient pitch-stirring excitations. These perturbation models were then used to predict blade flapping response to other pitch-stirring transient inputs, and rotor wake and blade-flapping responses to harmonic inputs. The viability and utility of using parameter identification methods for extracting the perturbation models from transients are demonstrated through these combined analytical and experimental studies.

78-616

On the Extensional Vibrations of Rotating Bars

D.H. Hodges

U.S. Army Air Mobility R&D Lab, Moffett Field, CA 94035, Intl. J. Nonlinear Mech., 12 (5), pp 293-296 (1977) 1 figs, 3 refs

Key Words: Cantilever bars, Rotors

The extensional equations of motion for a cantilever bar rotating about an axis fixed in space are derived. Studies are performed to determine the models required to simulate its behavior.

78-617

Interaction of Rotor Tip Flow Irregularities with Stator Vanes as a Noise Source

J.H. Dittmar

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-73706, 14 pp (Oct 1977)

Sponsored by AIAA

N77-32156

Key Words: Interaction: rotor-stator, Noise generation, Fans

The role of the interaction of rotor tip flow irregularities (vortices and velocity defects) with downstream stator vanes is discussed as a possible fan noise mechanism. This is accomplished by indicating some of the methods of formation of these flow irregularities; observing how they would behave with respect to known noise behavior; and attempting to compare the strength of the rotor tip flow irregularity mechanism with the strength of the more common rotor wake-stator mechanism. The rotor tip flow irregularity-stator interaction is indicated as being a probable inflight noise source.

78-618

Turbine Rotors Whirl After Dynamically Stable Designs are Uprated

F.L. VanLaningham

Union Carbide Corp., South Charleston, WV, Proc. 6th Turbomachinery Symp., pp 91-98 (Dec 1977) 9 figs, 5 refs

Sponsored by Dept. of Mech. Engrg., Gas Turbine Labs., Texas A&M Univ., College Station, TX

Key Words: Turbine components, Rotors, Whirling

The problem of steam turbine rotor whirling following uprating of a stable design and the measures taken to define the problem and implement a solution are described. Nearly identical units installed at several of Union Carbide's process plants exhibited different symptoms of minor instability after rerating. The newest unit, rerated before installation, began to exhibit signs of not-so-minor instability following a very stable and successful startup. The deceptive symptoms, temporary corrective action, final diagnosis of the problem, including field testing, are discussed.

78-619

A Unified, Variational Approach to the Analysis and Solution of Rotor Dynamics Problems

R.A. Mayo

Ph.D. Thesis, The Cooper Union for the Advance-

ment of Science and Art, 325 pp (1977)
UM 77-29,882

Key Words: Rotors, Dynamic response, Variational methods, Hysteretic damping

A rotor system's differential equations are derived using a systematic variational technique assuring the inclusion of all important effects. The technique permits the analysis of internal hysteresis effects. A new solution for the incompressible full bearing (Reynold's equation) is found using the variationally related sub-domain technique. The widely used short bearing approximation is found to be inaccurate even for very short bearings. A boundary condition parameter is derived, which permits the use of variable oil film interruption points occurring at zero pressure and zero pressure gradient. The time differential equations for the bearing forces are solved for the two limiting cases of the boundary condition parameter with complex Fourier series. The algebraic complexity of the dependence of eccentricity is simplified by the use of Lagrange interpolating polynomials.

78-620

High Stiffness Seals for Rotor Critical Speed Control

D.P. Fleming
Lewis Res. Center, NASA, Cleveland, OH, ASME Paper No. 77-DET-10

Key Words: Rotors, Critical speeds, Seals (stoppers)

An annular seal is analyzed in which the inlet clearance is larger than the outlet clearance; the flow path may be either stepped or tapered. This design produces radial stiffnesses 1.7 to 14 times that of a constant-clearance seal having the same minimum clearance. When sealing high-pressure fluids, such a seal can improve rotor stability and can be used to shift troublesome critical speeds to a more suitable location.

78-621

Computation of Unbalance Vibrations of Turborotors

E. Kramer
Darmstadt-Eberstadt, Germany, ASME Paper No. 77-DET-13

Key Words: Rotors, Turbomachinery, Unbalanced mass response

In order to see whether a critical speed of a turborotor is dangerous or not, computed unbalance vibrations are useful. For these computations several methods are known; however, because of the large number of possible imbalance distributions a large amount of data can be generated. To minimize the amount of data, it is proposed to assume the unbalance distribution as proportional to the normal modes of the individual shafts. The magnitude of eccentricities and of damping can be estimated by the results of unbalance runnings of individual rotor's field tests.

78-622

A Method for Investigating the Dynamic Behavior of a Turbomachinery Shaft on a Foundation

N. Bachschmid, B. Pizzigoni, and F. Di Pasquantonio
Politecnico of Milan, Milan, Italy, ASME Paper No. 77-DET-16

Key Words: Rotors, Turbomachinery, Machine foundations, Bearings

In this paper a method for studying the dynamic behavior of rotors is proposed, which takes into account not only the bearing characteristics but also the behavior of the foundation. The oil film and the foundation are studied separately thus obtaining both the stiffness and damping coefficients of the bearing and the mechanical impedances of the foundation at bearing locations. The influence of the foundation on the critical speeds of the shaft is shown. The results concerning a rotor of a 320-MW turbine placed on various foundations are ultimately shown.

78-623

Reliability of a High Speed Rotating Machine Subjected to Earthquake Excitation

T. Iwatsubo, K. Kawahara, N. Nakagawa, and R. Kawai
Kobe Univ., Rokko, Nada, Kobe, Japan, ASME Paper No. 77-DET-12

Key Words: Rotors, Earthquake response

High speed rotating machines, such as the centrifugal machines, may have errors in the mass, stiffness and damping coefficients generated by the manufacturing process, and also may be exposed to earthquakes. In the design of a rotor system, these factors should be accounted for from the view point of reliability. This paper deals with this problem. Specifically, if the statistical properties of errors of a rotor system and those of earthquakes (i.e., its period, magnitude, and statistical character of wave) are known, the statistical properties of the rotor vibration can be obtained, and a period of the first collision with the guard of the rotor system is calculated in a statistical sense.

SHIP

(Also see Nos. 506, 513, 514, 589)

78-624
Vibration Analysis in Motor Ship Maintenance
I.A. Rodger
Morley Ltd., Arundel, Sussex, UK, The Motor Ship, 58 (688), pp 86-87 (Nov 1977) 3 figs

Key Words: Ship, Diagnostic techniques, Vibration analysis

The application of vibration analysis as a condition monitoring technique is described. The technique is applied to auxiliaries associated with all classes of diesel engines - fuel and lubricating oil pumps, coolant pumps, centrifuges, blowers and compressors.

78-625
Dynamic Analysis as an Aid to the Design of Marine Risers
R.D. Young, J.R. Fowler, E.A. Fisher, and R.R. Luke
Harry J. Sweet & Associates, Inc., Houston, TX 77000, ASME Paper No. 77-Pet-82

Key Words: Computer programs, Ship structural component, Dynamic response

This paper describes a computer program for economically predicting the dynamic response of marine risers to lateral forces from waves (regular and random) and currents (vortex shedding). In addition to a technical description of the model, this paper discusses the differences in response between long and short risers and which physical parameters should be scrutinized in analyzing each of these. Also included is a method for estimating minimum tension requirements along with a discussion of "effective tension" in conjunction with the significance of buoyancy and mud weight.

SPACECRAFT

78-626
Simplified Dynamic Model of a Three-Axis Stabilized Satellite with a Two-Liquid Apogee Motor (Modele Dynamique Simplifie d'un Satellite Stabilise trois Axes a Moteur d'Apogee Biliquide)
J. Marce and A. Mamode
Centre National d'Etudes Spatiales, Toulouse, France, Rept. No. ESA-CR(P)-962, 112 pp (June 17, 1977)
(In French)
N77-32227

Key Words: Satellites, Mathematical models, Liquid propellant tanks

A simplified model of liquids in a full or partially filled apogee motor tank is established for a central tank configuration (spline divided into two compartments by a elliptical bulkhead), and a platform tank configuration (four spherical tanks), assuming three-axis stabilization. The motion of the perfect fluid is represented by a Stokes flow and a laminar wall boundary layer, for full tanks. A finite element method is used for calculation of the central tank, and an analytical method for the platform tanks. The surface parameters are calculated numerically using second order spline functions. Elements are given for calculation of the vibration modes during agogee impulse.

78-627
Thermally Induced Oscillations of Satellite Antenna Booms (Thermisch Induzierte schwingungen von Satelliten-antennenstaeben)
D. Peterson
Abteilung Festigkeits- und Stabilitätsprobleme, Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Brunswick, West Germany, In: Satellite Antenna Thermal Probl., pp 7-47 (Oct 1975)
(In German)
N77-32198

Key Words: Spacecraft antennas, Vibration response, Thermal excitation

The thermal induction of oscillations in the Helios antenna boom was investigated, notably whether the stiffening effect of the centrifugal force of the spinning probe would be sufficient to offset the oscillation. The differential equations describing the oscillation effect are discussed. The method applied to the Helios solar probe eigenfrequencies and eigenshapes is described. Results of the numerical analysis are presented.

78-628
Flutter of Control Surfaces with Structural Nonlinearities
R.M. Laurenson and R.M. Trn
McDonnell Douglas Astronautics Co., East St. Louis, MO, Rept. No. MDC-E1734, 111 pp (Aug 1977)
AD-A045 221/9GA

Key Words: Guided missiles, Flutter, Structural members, Aerodynamic loads

Missile control surface systems often contain structural nonlinearities which affect their performance characteristics and flutter boundaries. Presented in this report are flutter analysis procedures which have been developed to evaluate the potential influence of these nonlinearities on control

surface flutter. Three nonlinearities, freeplay, preload, and friction, have been investigated. The describing function technique, which has found application in dealing with nonlinearities in automatic control systems, has been used to mathematically represent these nonlinearities during the investigation. A simplified representation of the aerodynamic loadings acting on the control surface has been assumed. Techniques have application for either a rigid or flexible control surface. Numerous examples of the application of the developed flutter analysis techniques are presented.

STRUCTURAL

78-629
Coupled Dynamic Response Analysis of Modified Structural Branches
A.R. Kukreti
Ph.D. Thesis, Univ. of Colorado at Boulder, 298 pp (1977)
UM 77-29,940

Key Words: Transient response, Coupled response, Lumped parameter method, Modal analysis

A method of analysis is presented for determining the transient response behavior of a large structural system subject to changes of structural components. In this method the transient response characteristics of a complex structural system are used as a basis for evaluating the response of a similar system, identical to the original, except changes in one or more of the original subsystems. The method utilizes the lumped parameter model and modal methods. The analysis is limited to linear, conservative holonomic systems whose motion can be described by small displacement theory. The systems are considered to be in discrete form. Damping in the systems is assumed to linearly related to the stiffness.

TURBOMACHINERY
(Also see Nos. 539, 540, 574, 621, 622)

78-630
The Design of Support Structures for Elevated Centrifugal Machinery
M. Lisnitzer, D.C. Chang, and L.W. Abel
Pullman Kellogg, Div. of Pullman, Inc., Houston, TX, Proc. 6th Turbomachinery Symp., pp 99-105 (Dec 1977) 8 figs, 4 refs
Sponsored by Dept. of Mech. Engrg., Gas Turbine Labs, Texas A&M Univ., College Station, TX

Key Words: Machine foundations, Turbomachinery, Design techniques, Computer aided techniques

This paper briefly discusses the computer aided analysis and design of elevated turbomachinery support structures. Justifications to perform a rigorous computer aided analysis are given along with a succinct summary of the mathematical theory that enables the engineer to solve the large complex problem that represents the elevated turbomachinery support structure. Attributes of the computer aided technique are explained by presenting excerpts from typical example problems.

AUTHOR INDEX

CALENDAR

APRIL 1978

3-5 **Structures, Structural Dynamics and Materials Conference,** [ASME] Bethesda, MD *(ASME Hq.)*

9-13 **Gas Turbine Conference & Products Show,** [ASME] London *(ASME Hq.)*

17-20 **Design Engineering Conference & Show** [ASME] Chicago, IL *(R.C. Rosaler, Rice Assoc., 400 Madison Ave., New York, NY 10017)*

17-20 **24th Annual Technical Meeting and Equipment Exposition** [IES] Fort Worth, TX *(IES Hq.)*

24-28 **Spring Convention** [ASCE] Pittsburgh, PA *(ASCE Hq.)*

MAY 1978

4-5 **IX Southeastern Conference on Theoretical and Applied Mechanics** [SECTAM] Nashville, TN *(Dr. R. J. Bell, SECTAM, Dept. of Engrg. Sci. & Mech., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA 24061)*

8-10 **Inter-NOISE 78,** San Francisco, CA *(INCE, W. W. Lang)*

8-11 **Offshore Technology Conference,** Houston, TX *(SPE, Mrs. K. Lee, Mtgs. Section, 6200 N. Central Expressway, Dallas, TX 75206)*

14-19 **Society for Experimental Stress Analysis,** Wichita, KS *(SESA, B. E. Rossi)*

16-19 **Acoustical Society of America, Spring Meeting,** [ASA] Miami Beach, FL *(ASA Hq.)*

JUNE 1978

30 **Eighth U.S. Congress of Applied Mechanics,** [ASME] Los Angeles, CA *(ASME Hq.)*

SEPTEMBER 1978

24-27 **Design Engineering Technical Conference,** [ASME] Minneapolis, MN *(ASME Hq.)*

OCTOBER 1978

8-11 **Diesel and Gas Engine Power Conference and Exhibit,** [ASME] Houston, TX *(ASME Hq.)*

8-11 **Petroleum Mechanical Engineering Conference,** [ASME] Houston, TX *(ASME Hq.)*

17-19 **49th Shock and Vibration Symposium,** Washington D.C. *(H. C. Pusey, Director, The Shock and Vibration Info. Ctr., Code 8404, Naval Res. Lab., Washington, D.C. 20375 Tel. (202) 767-3306)*

17-19 **Joint Lubrication Conference,** [ASME] Minneapolis, MN *(ASME Hq.)*

NOVEMBER 1978

26-Dec 1 **Acoustical Society of America, Fall Meeting,** [ASA] Honolulu, Hawaii *(ASA Hq.)*

DECEMBER 1978

10-15 **Winter Annual Meeting,** [ASME] San Francisco, CA *(ASME Hq.)*

JUNE 1979

11-15 **Acoustical Society of America, Spring Meeting,** [ASA] Cambridge, MA *(ASA Hq.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS:	American Federation of Information Processing Societies 210 Summit Ave., Montvale, NJ 07645
AGMA:	American Gear Manufacturers Association 1330 Mass. Ave., N.W. Washington, D.C.
AHS:	American Helicopter Society 1325 18 St. N.W. Washington, D.C. 20036
AIAA:	American Institute of Aeronautics and Astronautics, 1290 Sixth Ave. New York, NY 10019
AIChE:	American Institute of Chemical Engineers 345 E. 47th St. New York, NY 10017
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ASQC:	American Society for Quality Control 161 W. Wisconsin Ave. Milwaukee, WI 53203
ASTM:	American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103
CCCAM:	Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada
ICF:	International Congress on Fracture Tohoku Univ. Sendai, Japan
IEEE:	Institute of Electrical and Electronics Engineers 345 E. 47th St. New York, NY 10017
IES:	Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056
IFToMM:	International Federation for Theory of Machines and Mechanisms, US Council for TMM, c/o Univ. Mass., Dept. ME Amherst, MA 01002
INCE:	Institute of Noise Control Engineering P.O. Box 3206, Arlington Branch Poughkeepsie, NY 12603
ISA:	Instrument Society of America 400 Stanwix St. Pittsburgh, PA 15222
ONR:	Office of Naval Research Code 40084, Dept. Navy Arlington, VA 22217
SAE:	Society of Automotive Engineers 400 Commonwealth Drive Warrendale, PA 15096
SEE:	Society of Environmental Engineers 6 Conduit St. London W1R 9TG, UK
SESA:	Society for Experimental Stress Analysis 21 Bridge Sq. Westport, CT 06880
SNAME:	Society of Naval Architects and Marine Engineers, 74 Trinity Pl. New York, NY 10006
SPE:	Society of Petroleum Engineers 6200 N. Central Expressway Dallas, TX 75206
SVIC:	Shock and Vibration Information Center Naval Research Lab., Code 8404 Washington, D.C. 20375
URSI-USNC:	International Union of Radio Science - US National Committee c/o MIT Lincoln Lab., Lexington, MA 02173